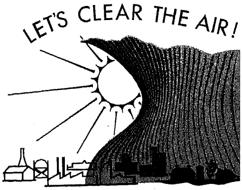
NATIONAL CONFERENCE ON AIR POLLUTION

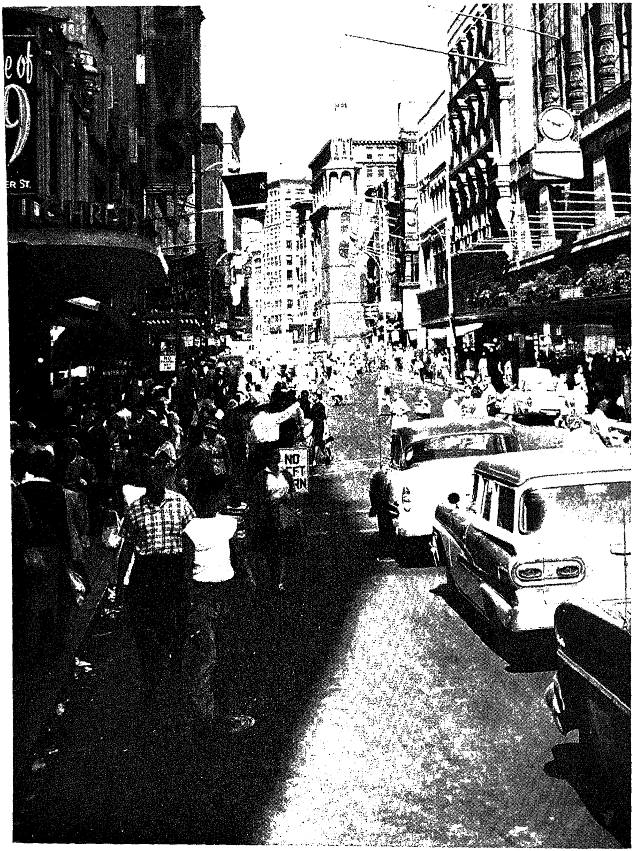
PROCEEDINGS



U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

We Cannot Confine Our Great Accomplishments to the Calm and Dispassionate Atmosphere of the Laboratory. We Must Move Out, Into the Sun and the Smog Where Ugliness Blights Our Fairest Cities . . .

LUTHER L. TERRY, M.D.
Surgeon General of the Public Health Service



National Conference on Air Pollution

PROCEEDINGS

DECEMBER 10–12, 1962
WASHINGTON, D.C.

CALLED BY THE SURGEON GENERAL OF THE PUBLIC HEALTH SERVICE

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
Division of Air Pollution
Washington 25, D.C.

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FOREWORD

Publication of the proceedings of the National Conference on Air Pollution of 1962 provides the Nation with a valuable and lasting guide, not only to the magnitude and complexity of the air pollution problem but also to the responsibilities that all of us will have to shoulder if the challenge of polluted air is to be met and surmounted.

A conference cannot provide all the solutions. But it can point the way toward placing in perspective issues and problems that have defied the best efforts to overcome them. This Air Pollution Conference was immensely successful in presenting for all of us a clear statement of the national problem of air pollution and the paths we must follow if we are to use our air resource in a way consistent with the highest ideals of human health and welfare.

These pages contain a wide range of opinion on many details of the air pollution problem. But what is perhaps more noteworthy, the proceedings show an almost universal agreement that greater action is needed now to reverse the trend toward unclean, unsightly, unhealthful air. Many who read these proceedings will contrast this meeting with the Air Pollution Conference of 1958, when the idea that air pollution might be sufficiently widespread and serious enough to warrant national attention was, if not novel, certainly less widely accepted than now.

What has changed in these 4 years, and in the months since the Conference, is the attitude toward air pollution held by people and organizations representing every segment of society. We who are directly concerned with the Federal responsibilities in air pollution receive much evidence that the American people want and insist upon clean air and are willing to strive for it. The Air Pollution Conference not only gave expression to the national demand for clean air, it also focused and heightened the need for the Federal Government

to assume the responsibilities of leadership in the air pollution field.

We have seen in the last few months increased congressional interest in proposals to increase both the size and the scope of the Federal air pollution program. In response to President Kennedy's health message delivered to the Congress on February 7, 1963, new bills have been intoduced in the Senate and in the House of Representatives to authorize the Department of Health, Education, and Welfare to provide greater assistance to State and local air pollution control efforts.

This Department subscribes now, as in the past, to the belief that the primary responsibility for air pollution control lies with that level of government best able to deal with the problem, and this means primarily State and local agencies. We believe further that the Federal Government has an obligation to provide the effective leadership that a growing air pollution problem demands.

The 1962 Air Pollution Conference left no doubt that substantially better control of this Nation's air pollution problems is within our reach, and it reiterated the compelling need for more responsible, more effective control programs. With these facts before us, and in the realization that polluted air is an environmental and social problem which we neglect at our peril, we can no longer postpone a strong and concerted effort to clear the air throughout the Nation.

ANTHONY J. CELEBREZZE
Secretary of Health, Education, and Welfare.

PREFACE

The 1962 National Conference on Air Pollution was called to provide a forum in which the many segments of American society involved with, and affected by, air pollution could present their ideas and recommendations for more effective control of a growing environmental problem. By this criterion, the conference was successful; for in these pages are contained the views of public administrators, scientists, physicians, engineers, industrialists, urban planners, and many others, who, taken together, truly represent the broad public on whose behalf the conference was called.

But the value of this conference must be judged also by a less tangible and more important measure: Did it bring closer to solution the issue to which it was addressed? Specifically, did it serve to help clear the air? To this question I believe we can also answer yes. I do not mean to suggest that the Nation has suddenly in the last few months departed on a path toward prompt and complete control of its air pollution problems. But I do believe that we have begun to appreciate more fully that air pollution is a challenge requiring not only national attention but also national effort. This conference has helped us to understand that we cannot divide ourselves into the separate camps of those who produce air pollution and those who suffer its effects. We are, all of us, in both camps; and we must now resolve to share in common both the responsibility for, and the benefits of, clean, healthful air. While there are differences of opinion on the nature of our individual responsibilities for the control of air pollution, I believe now that we do not differ in the conviction that greater resources must be brought to bear on this problem.

The challenge before us, as the conference emphasized, is great, but not insurmountable. A nation capable of producing industrial

and technological marvels, and translating them into the ingredients of a more useful and productive life for its citizens, can certainly protect its people from the unwelcome byproducts of a rising technology. This, a basic point of agreement at the conference, is a fundamental principle on which the Federal air pollution program rests. To find this point of accord expressed by conference speakers representing diverse segments of the American political, economic, and social scene gives cause for optimism, for it suggests that in view of what we know about air pollution, its effects, and its control, there is no real disparity between the national good and the individual good. They are one and the same.

It is a pleasure to express my appreciation to the more than 80 men and women who addressed the National Conference on Air Pollution and to the nearly 1,500 persons from this country and abroad who participated in it. Because of their efforts we may now begin to test the grounds for our optimism. The air has been cleared of many doubts which should no longer hinder our progress toward a more healthful environment.

LUTHER L. TERRY
Surgeon General
Public Health Service

INTRODUCTION

When Surgeon General Terry announced on April 30, 1962, that the Public Health Service would sponsor a National Conference on Air Pollution the following December, he set in motion an operation that was to culminate in what was perhaps the most influential and successful meeting in the history of air pollution control. Both the attendance at the conference and the public response to it throughout the country amply demonstrate that air pollution is a subject in which the scientific and engineering community, government, industry, and the people feel a sense of urgency and of opportunity. The conference theme, "Let's Clear the Air," was selected because it expressed not only the growing desire to take effective action against the rising trend of air contamination but also because it brought into sharp focus the need for a clear and precise statement of the scientific, technical, social, and political issues that are an integral part of the struggle for clean air.

A 20-member steering committee was appointed to work with Public Health Service staff in developing plans for the conference. Its membership included representatives of industry and labor, of civic and technical organizations, and of other public groups concerned with the control of air pollution. At a series of meetings in Washington, D.C., the committee helped to plan the broad outlines and many specific details of the conference. The committee endorsed the concept of a series of general plenary sessions on the first and third days and eight working panel sessions on the second day, these covering specific aspects of the air pollution problem. In all, some 90 persons were recommended to make formal presentations to the conference, and by mid-September, the steering committee had approved the detailed conference program.

The conference convened on December 10, 1962, in Washington, D.C. Owing to an intensive program of public information, the level of interest in air pollution and in the conference itself had been substantially increased. But another factor, the disastrous smog episode that had taken more than 300 lives in London a few days before the conference opened, added a feeling of urgency and tragic timeliness to the meeting.

Attendance substantially exceeded expectations. Nearly 1,500 persons from every part of the United States and several foreign nations registered for the conference. A breakdown of the registration list shows 486 representatives of industry, 263 Federal employees, 131 representatives of municipal government, 120 from State government, 55 county government officials, 54 persons representing research organizations, 177 from nonprofit organizations, 141 representing educational institutions, and 28 foreign visitors. The registration of representatives of the press and the broadcasting media was similarly greater than had been anticipated. More than 80 representatives of the various news media covered the conference. Press coverage during the 3-day meeting was extensive; radio and television broadcasts involving conference participants and the general theme of air pollution were carried by local and network stations; and at its close several national magazines featured articles summarizing the conference.

A variety of facilities and materials were available for those who attended the conference. Space was provided for a total of 34 exhibits from such groups as national trade associations, professional societies, governmental agencies at all levels, educational institutions, and nonprofit research organizations. Perhaps the most visited exhibit was the geodesic dome erected on the hotel grounds, which housed the Washington, D.C., Continuous Air Monitoring Station and provided visitors daily readings for pollution levels in the air of the Nation's Capital.

In order to provide conference registrants and participants with background material on air pollution, 14 publications were prepared and edited for initial distribution at the conference. These included a chart book and a fact book, each of which presented general information on the air pollution problem and the control effort nationally; digests of State and municipal laws and ordinances; a selected bibliography of air pollution publications; a compilation of measurements of the Public Health Service's National Air Sampling Network, 1957–61; and a summarization of current air pollution research activities in the United States. As a further aid to those attending and participating in the conference, all papers and speeches presented during the meeting were available in the form of preprints, of which some 75,000 were distributed at and following the conference. Major portions of the conference were recorded on tape and film for later use in making available the valuable information presented by conference participants.

Elsewhere in this Proceedings are the names of many persons, both within and outside the Federal Government, whose contributions helped the National Conference on Air Pollution—1962 to achieve the impressive success that has been attributed to it. These

served, and the men and women whose professional lives and careers are dedicated to controlling the problem of air pollution. I wish also to extend sincere thanks to the many organizations and individuals who volunteered facilities, services, and personal effort on behalf of the conference. Their contribution was invaluable in helping the conference live up to its theme and goal, "Let's Clear the Air."

ARTHUR C. STERN
Executive Secretary
National Conference on Air Pollution

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FIRST PLENARY SESSION

It is imperative that this Nation act to preserve now, and for the years ahead, the purity of its air. The pollution of this priceless resource continues to jeopardize the economic vitality of our Nation and the health of millions of our citizens. This fact we can neither condone nor tolerate; we can and must, instead, resolve to use every appropriate means in a concerted effort to clear the air of its burden.

It is my hope that this Conference will provide the wise counsel and informed guidance that will hasten the needed action on this problem. I urge every American to lend his full support to this endeavor.

JOHN F. KENNEDY
President of the United States

Conference Keynote

PARTICIPANTS

Chairman: ROBERT J. ANDERSON, Chief, Bureau of State Services, Public Health Service, Washington, D.C.

ARTHUR C. STERN, Executive Secretary, National Conference on Air Pollution, Public Health Service, Washington, D.C.

ANTHONY J. CELEBREZZE, Secretary, U.S. Department of Health, Education, and Welfare, Washington, D.C.

LUTHER L. TERRY, Surgeon General, Public Health Service, Washington, D.C.

S. SMITH GRISWOLD, Control Officer, Air Pollution Control District, County of Los Angeles, Calif., and President, Air Pollution Control Association, Pittsburgh, Pa.

INTRODUCTORY REMARKS

ROBERT J. ANDERSON
Chief, Bureau of State Services
Public Health Service,
Washington, D.C.

I welcome you to this second National Conference on Air Pollution. The first National Conference on Air Pollution was devoted to analyzing what we knew or did not know about air pollution, so that we could begin working on the research programs that would provide the missing answers. That was 4 years ago. Now we are here to explore what we can do about it. The theme of this conference is "Let's Clear the Air."

I hope that the wonderful weather we are having outside today will prove to be a happy augury for the results of our deliberations here. The heavy, still, stagnant air mass that hung over the eastern seaboard of this country for the past 10 days or so seems to have moved on, taking with it the air pollution concentrations that were climbing to high figures. In London, too, the heavy smog which occurred there last week is also lifting and moving on.

In that connection, I have some news from our associate, Dr. Richard A. Prindle, who is now in London observing at firsthand the results of the tragic new smog episode which struck that vast city a few days ago. He left Washington as soon as we got word of the buildup of pollutants in the London area and, of course, in order to get there in time to make direct observations, he had to fly. But planes weren't flying into London last week; last Wednesday, the visibility there was only about 15 feet. So he had to detour via Frankfurt, Germany, and complete the last leg of his journey by train.

Yesterday we had a report from Dr. Prindle by phone. While the smoke is probably somewhat less, the pollutant concentrations seem to be at about the same level as in the disastrous smog of 1952. On Wednesday, sulfuric acid in the London atmosphere measured six-tenths of a milligram per cubic meter, and the sulfur dioxide concentration was two parts per million. By Friday, the latter had fallen to three-tenths of a part per million. With regard to health effects, there had been, in the 3 days through Wednesday, 394 emergency hospital admissions relating to respiratory conditions. This figure compares to about 489 in 1952. The number of deaths occurring on the streets alone totaled 106 through Wednesday. These are the deaths which are usually reported immediately through police channels; they do not include excess deaths which may have occurred in homes or hospitals. The totals will become available only as the city's vital records are analyzed later. Tentative British estimates of economic losses due to the eight work stoppages and interference with air and surface transportation are put at $30 million.

Dr. Prindle will, of course, continue to observe developments in this latest of the so-called "acute" air pollution episodes. Meanwhile, it serves to underline for us the fact that we are considering here a serious problem, a problem which has an important bearing on industrial life and metropolitan life throughout the world.

ANTHONY J. CELEBREZZE
Secretary of Health, Education, and Welfare
Washington, D.C.

It is a pleasure to welcome you and to thank you for having taken time from your busy schedules to participate in this National Conference on Air Pollution. The tragic news from London that another serious smog episode has crippled and killed an as yet uncounted number of people in Great Britain adds a special note of urgency to our meeting. It will take many months, perhaps even years, before the full toll of damage, death, and disability has been computed. Even under the extreme circumstances of this air pollution disaster, it will be impossible to gage the full dimensions of the calamity until it has become history. If we must wait for the verdict of history on an event so obvious and so tragic, we need not be surprised if in 3 days a perfect consensus is not achieved here in our attempts to explore the full scope of air pollution.

The problems of our urban environment are more frequently subtle than obvious. As the former mayor of a large American city, I have had the privilege and the responsibility of meeting these problems at the local level. This level, all things considered, is our first line of defense against both the direct and the indirect threats to public health and welfare. By direct threats I mean those which receive most of the headlines—accidents, robbery, murder, fire, and storm. I mean also the many other visible natural and manmade hazards to person and property that a civilized community must control. The indirect threats are those which do not show themselves on the police docket, which invade the privacy of home, factory, office, and school in slow and subtle ways . . . the pollution of lakes and streams, the necessary but sometimes too extensive domination of trees and grass by brick, asphalt, and cement . . . the slow and steady adulteration by pollutant gases and smoke of the air we breathe. This last is a process so hidden that for days on end, when wind and weather are right, we may not even be aware of it.

Having dealt with both the direct and the indirect problems of government at that level where their impact on people is most clearly evident, I can assure you that the direct problems receive the most direct attention. They are, after all, the problems that civilized communities have had to deal with throughout the entire span of recorded history. They are problems that we know best how to deal with.

But now we must enlarge our field of vision to include also the indirect problems that our modern way of life has thrust upon us. To deal properly with these, we must recognize the overriding importance, at this stage of our development as a nation, of creative and sincere cooperation among all the elements of our society. All have an important role to play in molding the outlines of the present which will determine the patterns of the future.

The first area in which cooperation is needed is among the various levels of government. As I said at the National Press Club not long ago, the primary tasks of providing adequate health, education, and welfare measures and facilities are a responsibility of the State and local governments. I added that the purpose of our Federal programs is to stimulate local initiative and, as I shall illustrate when I come, in a few moments, to needed legislation, local initiative cannot be stimulated unless local governments possess the financial and technical resources for dealing with both their immediate and their long-range problems. A government which is straining to provide enough policemen and firemen for public protection can hardly respond adequately to stimulation in the field of air pollution control which consists mainly

of vocal urgings. It needs, especially at first, enough financial and technical assistance to allow the full recognition and appraisal of long-range problems. This will demonstrate to the local public what steps they must take, and what benefits they can expect from shouldering these new responsibilities.

I feel certain in my own mind that our citizens will accept whatever responsibilities are called for—once the need has been demonstrated—to insure clean air for themselves and their children. There is no doubt at all that citizens, properly informed, will be willing to pay for control measures which—not to mention the health hazards—cost far less than the dollar damages from polluted air.

The cooperation of industry is just as essential as cooperation among the several levels of government. While short-term objectives may differ, the long-term interests of government, of industry, and of every member of the public are virtually identical. It could not be otherwise. Because—all taken together—we *are* the public, and whether we work in government or in industry, or have finished our working years, we all share the same busy streets, the same water, and the same air in our great metropolitan areas. It is in the hurried pursuit of short-term gains that we sometimes lose sight of the mutual gain which comes from dealing properly with mutual long-range problems. The establishment of responsible and equitable control programs at the local level is therefore of direct advantage to the farsighted who can see the basic interdependence of private and public interests.

As mayor of Cleveland, I acquired some firsthand evidence of what can happen, to the public benefit, when industry acts in recognition of this interdependence. To mention a single example, I had the pleasure, almost exactly a year ago, of turning a switch at a great steel company in that city. A tall stack which had been pouring out clouds of red smoke ceased immediately to do so. The switch I turned put into operation a $2,500,000 precipitator which will help protect the air that is breathed by more than 2 million people of Greater Cleveland.

I should like to add in this connection that, during my whole tenure as mayor of a large industrial city, I found industry very responsive in taking steps—both on its own initiative and in cooperation with the air pollution control agency—to prevent or correct conditions which pollute the atmosphere. This has often involved a very substantial capital investment, but industrial leadership recognized the necessity for that investment. I might say to those of you who work on the local level that it pays to sit down with the industry leaders of your community and make known to them the problems which exist; if you have a workable solution to the problem, discuss it with them, and form a team—a cooperative team—to combat the air pollution, rather than each other. In my opinion, neither side wins if you are constantly at loggerheads with one another.

The simple act of turning that switch I mentioned was actually the end product of a long series of complicated negotiations and a full exchange of points of view—that is to say, that constant and creative debate which is so necessary to our way of government. The industry's recognition of civic responsibility was one factor, but another of no less importance was Cleveland's air pollution control program. Not only was the local control agency able to advise the industry and evaluate its control efforts, but also, the existence of this agency provided a guarantee that those responsible for other sources of air pollution would be encouraged to face up to their civic obligations. To honor guarantees such as this, local control agencies today need to have the manpower, the technical knowledge, and the equipment to deal with a much wider range of air pollution problems than those presented by a single steel mill or, for that matter, by all of industry. They must also deal with a broad category of municipal sources, with motor vehicle emissions, and with a long list of residential and commercial sources.

Since its inception, the Federal program has devoted its full resources to providing assistance to the local and State authorities, whose jobs have grown more difficult in the last decade. Federal research on the health, the economic, and the control aspects of air pollution has provided better tools for those directly responsible for control. Federal technical assistance activities have helped many States and communities to assess their problems and determine sound remedial procedures. Likewise, Federal training and educational efforts have helped develop needed technical skills as well as a better understanding of the problem. Investigation into control techniques—from motor vehicle tailpipes to factory stacks—like most of our activities, has been of value to industry as well as to control authorities.

Despite the considerable progress we have made, large numbers of people in our urban areas are not now served by adequate local control programs.

It was in the light of this important fact that the President presented to Congress in its last session a bill designed to assist State and local governments in meeting their responsibilities.

As some of you may know, this bill placed emphasis on the responsibility of State and local governments for regulatory actions. It provided for amplification of the research, technical assistance, and training activities which have been the foundation of the Federal air pollution program since its inception. The most important new provision it contained would have authorized the Public Health Service to provide financial aid to States and local governments through grants of limited duration. Such grants would assist in the appraisal of air pollution problems, in the initiation of control measures, and in the improvement of existing programs. Grants of this type, for development and improvement of local programs, have a long history of success in public health and welfare activities.

However, in the press of time and in view of the large number of new proposals offered during the last session of Congress, this bill was not acted upon. But the same air pollution problems which faced us last year face us now, and we are no less obligated to provide the leadership which the President has called for.

Our Department is studying the proposals included in last year's bill, and we may safely assume that the Congress will conduct similar studies. You may be sure also that the most careful consideration will be given to any recommendations that may come from this conference or which may be offered by any organizations or individuals represented here.

While many of us attending this conference must give concentrated attention to the immediate and pressing problems of air pollution, I should like to us, but we must at the same time increase our vigilance in regard to those problems of environment which those who follow us will inherit. We must now and then look beneath the topmost and most glamorous layer of life in our era to observe the undesirable side effects which may accompany our progress. We must find ways to secure the benefits of change and avoid the hazards and costly penalties. In our planning we must learn to weigh the good results of our actions against the bad, and make our decisions with full awareness of both.

My experience has convinced me that we must increasingly think of our urban environment, and deal with it, as a whole—as a single unit with closely interrelated and interdependent parts. In our modern cities we cannot separate housing from health, or either from transportation, or any of these from the resources of our natural environment, such as air and water.

Certainly, with all the wonders of modern science and technology at our command, we can, if we have the will, build cities more beautiful than have ever been seen before in history. I am not talking about Eldorados of the imagination, with streets paved with gold, or milk and honey flowing from the fountains—but about cities which are real, yet still keep man in touch with the natural heritage which was his before the first city was built. Such cities would provide us with beautiful vistas, shady groves, and clear waters—and they would be inconceivable without a constant supply of fresh, clear, healthful air.

An ancient Persian poet had a word for it, or rather, 15 words, and I hope we can also some day translate these words of Omar into action. Let us try, as he said, "to grasp this sorry scheme of things entire . . . and remold it nearer to the heart's desire."

LET'S CLEAR THE AIR

LUTHER L. TERRY
Surgeon General
Public Health Service
Washington, D.C.

It is a pleasure to welcome you to this national conference and to thank you for devoting 3 days of your time to the problem of air pollution. Between now and next Wednesday evening you will be called upon in plenary and panel sessions to grapple with the many diversified and complicated issues associated with air pollution. The extent to which you succeed in clarifying these complexities will determine how close we come to achieving our deceptively simple conference objective, "Let's Clear the Air."

By the end of our sessions on Wednesday we shall not have achieved a miracle. The filters of air-sampling devices throughout the country will still come out in varying shades of dreary gray and deepest black. Nevertheless, if we keep sight of our objective and help clear the air of many unresolved issues that cloud the problem, a favorable change in air-sampling results will follow in due time. That, after all, is why we are here.

Air is the medium on which all human activity depends. It is not surprising, then, that the adverse effects of air pollution are many and varied. Moreover, virtually everyone is responsible to one degree or another for the problem. These are the characteristics which mark air pollution as a prime problem of the contemporary environment and account for the fact that we represent such a wide range of interests, organizations, and professional disciplines.

Many of you who are here today contributed to the remarkably successful Conference on Air Pollution held in 1958. Why then, if that conference was successful, are we holding another now? What have been our accomplishments since then? Which problems remain the same? Which are different? And what are our needs for the future?

Certainly the fundamental facts of life in a nation of advanced technology, which faced us in 1958, are still with us today. There are no signs on the horizon to suggest that man's capacity for fouling his nest has lessened. Indeed, there have been signs of an ever-growing capacity to produce—by chance or by choice—dramatic alterations in the conditions of human life. Urbanization continues; the great demands for more products, services, and energy continue; the mechanization and automation of many human activities grow.

Beneath all these manifestations of change, in fact, the very root from which they grow and flower, is an ever-increasing proliferation of scientific knowledge. It is this knowledge which enables us with an ever more subtle certainty to chart the far-ranging course of satellites in space and—at the other end of the scientific spectrum—to map the genes on a chromosome. Yet today, as in 1958, many of the problems of how to employ this burgeoning scientific knowledge within the context of the social, economic, and political framework of our society continue to confound us. We are so sophisticated scientifically that men can breathe in the airless void beyond the earth's atmosphere. And yet we are so primitive that the quality of the air we breathe on the surface of the earth continues to deteriorate.

Since it is our task to help rectify such incongruities, our work is bound to be difficult. Real solutions to the problem of air pollution will require an enlargement of our vision and the serious contemplation of the other side of a lot of old coins whose one side we have long been accustomed to. We must address ourselves to the entire problem in all of its staggering breadth and scope and not confine ourselves to its undeniably important, but

essentially noncontroversial, technical aspects. We must place at least equal emphasis on how to apply what we already know.

Air moves or doesn't move as natural forces dictate. The artificial lines we place on our maps do not trammel it. And the dozens of jurisdictions into which we fragment our metropolitan areas trouble the air not at all. What troubles the air is the burden of pollutants we ask it to carry. This burden promises to become greater, ironically, in direct proportion to our success in increasing our general prosperity.

The trends of technological growth assure us in advance that smoke and fumes, dusts and gases, will move into the air from more points on the urban scene. Growth of the air pollution problem, therefore, is automatic—no study is required, no committee meetings, no compromises—not a harsh word nor a single glimpse at a point of view that has not already worn comforting grooves in our consciousness. The control of air pollution, on the other hand, is in no way automatic, and there is no advance assurance that our efforts to deal with the problem will be adequate. These efforts must be deliberately and conscientiously planned.

During the next 3 days virtually every important health, economic, and social aspect of the air pollution problem will be the subject of expert discussion. When the discussions are over we should be in a better position to determine precisely where we stand.

Today, however, we begin our appraisal from a more advanced vantage point than had been reached 4 years ago.

Our knowledge of the health effects of air pollution has been amplified considerably through three types of investigations: statistical studies of past illness and death as correlated with geographic locations and other factors associated with air pollution; epidemiological studies of death and respiratory function as related to variations in air pollution; and laboratory studies of responses by animals, and in some cases by human beings, to exposure to various pollutants or combinations of pollutants.

This is not the occasion to recapitulate all of the investigations that have been conducted. A thorough review of health studies related to air pollution will no doubt occur tomorrow in the panel sessions. However, I should like to highlight briefly just a few of the investigations which have augmented our store of knowledge.

Studies have shown that death rates for cardiorespiratory causes correlate in general with air pollution levels; that asthmatic attacks among susceptible patients correlate with variations in sulfate air pollution in Nashville, and that asthma attacks in New Orleans may be associated with air pollution resulting from the incomplete combustion of refuse. Employee absenteeism due to respiratory illness has been correlated with levels of sulfate pollution. Another study demonstrates that people living in a town where pollution is high display significant differences in average airway resistance when compared with those living in a town where pollution is lower. It has been brought to light that more than 200 excess deaths occurred in New York City in 1953 during a period of air stagnation.

Laboratory studies involving exposure of animals and, in some cases, human beings to controlled concentrations of gaseous pollutants, such as ozone and sulfur dioxide, agree generally with the results of epidemiological studies. One of the most significant investigations of this type resulted in the development of lung cancer among laboratory animals infected with influenza virus and later exposed to the inhalation of an artificial smog consisting of ozonized gasoline. Mice exposed to either influenza or ozonized gasoline singly did not develop lung cancer.

These are but a few of the highlights of health investigations carried out in the past few years. There have been many others and, when combined with past studies on the subject, they form a considerable body of evidence which makes it unmistakably clear that air pollution is associated with such important respiratory diseases as lung cancer, emphysema, chronic bronchitis, and asthma.

What does this association mean? Does it mean that air pollution causes these diseases? If not, is there nothing to fear from air pollution as a public health problem?

Before these questions can be adequately answered, it is necessary to examine what is meant by the term "cause" when we speak of the chronic diseases associated with air pollution.

I submit that much of the speculation and controversy about whether or not air pollution causes disease is irrelevant to the significance of air pollution as a public health hazard. We are accustomed to thinking that a disease state is brought about by a single cause—a carryover from a period in public health history when virtually total em-

phasis was placed on *the* bacterial or viral agent which had to be present before a communicable disease could be recognized and dealt with. That there is frequently a simple association between an infectious disease agent and the acute disease reaction which it provokes was once a startling revelation. And in public health it has served us well and continues to serve us well. But we have learned that it is not the master key that unlocks all the secrets of disease and health. The idea that one factor is wholly responsible for any one illness is patently too simple to provide all the answers we need to deal with the chronic diseases which are on the rise today.

Chronic bronchitis, which in Great Britain is established as a specific disease entity, is a good example. It develops over a long period of time and can become crippling through a combination of many factors—air pollution, smoking, repeated and recurring bouts with infectious agents, occupational exposures—all affected, perhaps, by an hereditary predisposition. What then is *the* cause of chronic bronchitis? The answer is obvious. There is probably no single cause, but there is sufficient evidence that air pollution can and does contribute to its development. This is what really matters, whether we choose to consider it *the* cause, one of several causes, or simply a contributing factor.

New criteria must be employed in assessing the damage of air pollution—criteria which include statistical evidence that a disease condition exists in a population, epidemiological evidence of the association between the disease and the environmental factor of air pollution, reinforced by laboratory demonstration that the air pollutants can produce similar diseases in experimental subjects. Ideally, all of these observations should be underlined by the ultimate demonstration that protection against air pollution will lessen or remove the severity of the disease.

There are still great deficiencies in our knowledge. We need to learn more about the pollutants which affect health—and in what amounts and under which conditions. But the qualitative evidence at hand conveys a clear message. There is no longer any doubt that air pollution is a hazard to health—the entire complicated and often misconstrued question of "cause" notwithstanding.

In addition to its effects on health, air pollution places a heavy economic burden on the country. It causes extensive damages through its effects on animal and plant life, through corrosion and soiling of materials and structures, depreciation of property values, interference with air and surface transportation through reduction in visibility, and losses of unburnt fuel. These matters, too, will be discussed in depth in the next 3 days. I would say simply that estimates of such losses have tended to increase in recent years. The latest figures suggest that air pollution may be costing the Nation more than $7 billion each year.

Because the economic and health effects of air pollution are related in a number of important ways, our efforts are not, and cannot be, confined to health effects alone.

New and valuable information on levels of air pollution throughout the Nation are being made available through the cooperative local, State, and Federal National Air Sampling Network which now operates in every State, in 213 urban and 37 nonurban sampling sites. In addition, we now have a Continuous Air Monitoring Program which provides what is virtually a minute-by-minute appraisal of the levels of gaseous pollutants in nine major cities.

A 2-year study on auto exhaust and health has been completed under Public Law 86–493, passed in 1960. The report to Congress, "Motor Vehicles, Air Pollution, and Health," makes clear that research has shown that automobile emissions do produce adverse effects on human health and other biological systems. It points out that it is possible that none of our present approaches will, in the long run, provide adequate solutions to the problem. Entirely different concepts may be needed, such as the modification of basic engine design or employment of types of engines not now commonly in use.

We have made progress in assessing the quantities of individual pollutants present in the atmosphere. An example is the number of studies published on comparative levels of benzpyrene in cities throughout the country.

We have accelerated our work on the investigations of techniques and basic design considerations, not only as they relate to the pollutants produced by automobiles, but also for other ubiquitous pollutants, such as the oxides of sulfur, for which adequate means of control are not now available.

We have stepped up technical assistance activities. We have completed 13 cooperative statewide surveys as well as 10 major local surveys and dozens of investigations of special air pollution problems.

We have augmented our training efforts. Up to the present, training at the Public Health Service's Sanitary Engineering Center in Cincinnati and in the field includes courses in 18 different subject areas. Research and training grants to universities and other organizations have increased from 31 in 1958 to 85 at the present time.

In a number of ways we have lent assistance to the State of California, which has taken unprecedented steps toward the control of air pollution. California has established the first statewide health standards for pollutants in community atmosphere and has greatly stimulated the development of control devices for automobiles. Among these is the crankcase ventilation, or blowby device, which is offered voluntarily by automobile manufacturers as standard equipment on all new American cars now available. In addition, California legal requirements have stimulated the development of devices to control the major source of pollution from automobiles, engine exhaust fumes emitted through the tailpipe.

I have pointed out only a few of the landmarks of progress over the past few years. There are many others. They add up to a valuable harvest of information on the effects of air pollution on man, on agriculture, and on our economy.

Federal activities in air pollution are guided by the basic concept that the Federal role should be one of providing leadership and assistance toward obtaining the common objective of cleaner air, in cooperation with all other levels of government, industry, and other interested elements of our society. All of our activities are designed essentially to support State and local governments, which have the primary responsibility for the control of air pollution. The extent to which industrial and other organizations, and individuals, control the pollution for which they are responsible depends directly on the effectiveness of State and local programs.

The number and effectiveness of these programs provide the best yardstick by which we can measure our success, or lack of it, in translating our growing knowledge into concrete action.

A glance at this yardstick shows how far we have yet to go. Approximately 90 percent of the urban population live in localities with air pollution problems—a total of about 6,000 communities. But only half of this population is served b
trol programs with full-time staffs.
about 100 such programs, serving

about 10 cents per capita, an amount clearly inadequate to do the job which is necessary.

During the past decade there has been some improvement in the status of State air pollution legislation and in the development of comprehensive programs. About 15 States now authorize the conduct of specific programs, whereas no State had such authorization in 1950. These relatively new air pollution programs are quite variable with respect to their activities, and most operate under severe budgetary restrictions.

If we are going to clear the air, then, it is particularly important that State and local air pollution control programs be extended in coverage and strengthened in depth.

We can assist through an expanded program at the Federal level. We could then provide better appraisals of the present and potential air pollution problems in specific localities. We need improved methods and instrumentation for recording emissions and determining atmospheric levels of pollutants and their effects. We need to help develop administrative procedures which will be useful in resolving interjurisdictional problems.

In addition, it may well be that new means are needed to stimulate the development, improvement, and extension of local air pollution control programs. One which has served well in other areas of health is financial stimulation by means of grants for specific local and State projects.

In the long run, the view the public takes of air pollution will determine the extent to which all of us—in government, industry, and elsewhere—meet our obligations in this area. Precisely how the public feels about air pollution is a very subjective matter and is not easy to gage. Yet there are several discernible signs of growing public interest.

The concern shown in recent years by scientific, civic, and social organizations, for example, is objective evidence of this interest. Some groups have long been involved with the problem; others have moved into the field since the last national conference was held. Their number and diversity are reflections not only of widespread public interest but of the many ramifications of the air pollution problem.

Of no less importance is the fact that information on air pollution has been made both more accessible and more understandable to the layman as well as to the expert through greatly augmented attention by the public media—newspapers, radio

and television, and periodicals. Air pollution has, in short, become a part of the public consciousness.

This evidence of broad awareness represents progress just as surely as do new research and control developments. Our most important task at this conference is to find ways of channeling the knowledge we have and the interest we have observed into creative programs of action.

The challenge is great, for the problem of air pollution is an inseparable part of one of the most important needs of our time: the creation, in our era of accelerating change, of a healthful environment worthy of our high level of economic development and scientific achievement.

There are those who feel that our age and our country no longer offer new challenges. They somehow see in urbanization and the loss of our geographic frontiers an automatic loss of the spirit of adventure. Some would equate the fact that you cannot drive a herd of cattle from Cheyenne to Dodge City without using wire cutters with an irretrievable loss of liberty and self-determination.

I cannot accept this point of view. The horizons of American life were never more challenging, the adventures never more exciting, nor potentially more rewarding. We have a new frontier to conquer. I refer neither to our vanished Western frontier, of which the cowboy is still an enduring symbol, nor to the new frontier of interplanetary space symbolized by the spaceman. I refer rather to the frontier which can be conquered only through the creation of a physical, social, and cultural environment in which people can achieve the highest possible levels of health—an environment in which, to paraphrase a famous statement by William Faulkner, mankind may prevail, not merely survive. This challenge offers opportunities for adventure second to none in importance, and will benefit millions of people alive and more millions yet unborn. Even after it has become commonplace to stand on the moon breathing smog-free air under an artificial canopy, people will still need to find their essential fulfillment here on earth.

To achieve this kind of environment we must take full cognizance of the great acceleration in scientific accomplishment which has attained so fantastic an impetus in recent generations. A decade now brings changes demanding much greater adaptations in our habits of body and mind than a millennium did during the vastly greater portion of man's existence on earth. We cannot confine our great accomplishments to the calm and dispassionate atmosphere of the laboratory. We must move out, into the sun and the smog, where ugliness blights our fairest cities; where rivers which once moved clear and blue are now laden with filth; where traffic stands still and there is no place to walk; where chronic diseases continue to rise in an era of unparalleled affluence; and where health is still regarded, by and large, as a negative condition in which there is an apparent absence of pain or disability.

Since modern man can determine the nature of his environment, he must learn to accept responsibility for its deficiencies in much the same way that he accepts responsibility for his individual acts. Otherwise, our repeated pleas for cooperative effort and shared responsibility have a hollow sound. If a crime is committed, we are quick to bring the immense weight of civilization to bear upon the guilty one, but what about the crimes that we commit as a group? These are offenses we commit against ourselves—often in good faith and with the most highly sanctioned of motives.

From this point of view, Donora was a crime. The deaths from chronic diseases associated with environmental factors which occur daily are also crimes. Who is to blame? Where are the culprits? What should we do to apprehend them? Where? Everywhere. We are all guilty—not health officials alone, nor legislators, nor businessmen—but all of us.

Certainly now, when we can and do determine—by chance or by choice—the structure of our environment, we cannot blame the vagaries of nature for its defects. That time is past. *We* are responsible. During the next 3 days we have an opportunity to discharge an important part of our awesome responsibility. Let's get on with it! Let's clear the air!

APPROACH TO AIR POLLUTION CONTROL

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What is done on the national and State levels to control air pollution is of undeniable importance, but ultimately, control of stationary sources remains a matter for community action. For that reason, I would like to respond to the remarks of the Surgeon General on behalf of the person who is perhaps the most important participant at this conference—the man at the action level, the community leader who recognizes that he is not an expert and who has come here to learn.

The most important impression we can take away from this conference is the knowledge that there are existing solutions ready for us to apply to almost every air pollution problem. We should resolve to apply these solutions reasonably to the particular problems of our communities.

In the last few years we have found that few communities have the same total air pollution problem. In Los Angeles 80 percent of our problem is motor vehicle emissions; 20 percent comes from industry and other sources. In neighboring San Francisco, the problem is approximately 60 percent vehicular and 40 percent industrial. In Los Angeles we burn no coal and relatively little fuel oil; in Pittsburgh coal burning was once the major source of air pollution. In Los Angeles our air is very stable; we have light winds and low inversions. In Chicago and Cleveland the winds are brisk and inversions are rarely a problem.

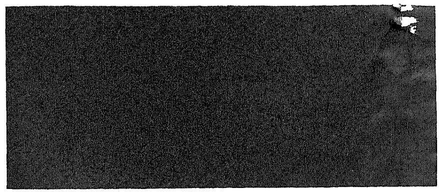
Despite this overall dissimilarity, the individual components of the problem are similar and the same correctives may be applied wherever those components are important. A steel furnace in Pittsburgh can be controlled in the same manner as a similar one in Los Angeles. A catalytic cracker in New Jersey can be controlled to the same degree as one in San Francisco. The same control devices and techniques that have been developed in one area may be instituted in another.

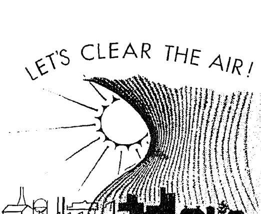
During the course of this conference we are going to find that there already exists a great deal of practical knowledge about the nature of air pollution and what can be done to control it. It is most apparent that the principal difficulty for a community embarking upon a control program is in deciding what to do and to what degree. Making this decision calls for a broad view, embracing many considerations that are outside the usual conception of air pollution and its control.

One of the basic motivations for cleaning up the air is to improve the health of the community. However, the more deeply we examine the health effects of air pollution, the less satisfied we are with our existing knowledge. The cause-and-effect relationships are difficult to establish, and this information comes slowly. Thus, despite the underlying importance of the health issue, there probably is no air pollution control program in the Nation today based upon anything stronger than the knowledge that air pollution cannot be good for people. If you want to begin cleaning up the air of your community now, you may have to rest your arguments about health upon this assumption, and look for other reasons to control air pollution.

After all, most communities do not wait for medical proof that roadside litter is a hazard to human health, nor do most citizens mow their lawns in order to prevent the spread of disease. Neither should we control air pollution solely to prevent pub-

SECOND PLENARY SESSION





Statesmanship in Air Pollution Control

PARTICIPANTS

Chairman: JOHN E. FOGARTY, U.S. Congressman, Providence, R.I.

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SCIENTIFIC STATESMANSHIP

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That science should require the guidance of statesmanship and statesmanship the discipline of science is a special mark of these disjointed times. Science, which is at its source an encounter of a single mind with the stern reality of nature, would appear to have no cause to weigh the wisdom of its inevitable course. The affairs of state, which are guided by values that are remote from natural law, have seemingly little need for the discipline of science.

Why then have science and statesmanship become—as they now are—so closely intertwined? Seventy years ago Pasteur could advise students, "Whatever your career may be, do not let yourselves be discouraged by the sadness of certain hours that pass our nations. Live in the serene peace of laboratories and libraries. . . ." Why has the serenity of the laboratories been swept away by intruding social problems? Why has the discipline of science now intervened in the councils of state? Where in this tangled design lies the duty of the scientist to society, to science, to himself?

The answer, I believe, lies in understanding the paradoxical effects of scientific progress on the welfare of man. Nowhere is this paradox more acutely revealed than in the problem of environmental pollution.

This conference is concerned with finding ways to free the air of its growing burden of pollution. That such a conference should be necessary at this time sharply illuminates the conflicting effects of science on society.

We are living in a time of astonishing scientific progress. Scientific research has become a powerful tool for analyzing the natural world, from the depths of the earth to the outer reaches of space. Evidence of its success—the wonderful harvest of technological applications—is all around us: space vehicles, nuclear power, numerous new synthetic chemicals, great improvements in the practice of agriculture, medical advances which have significantly increased the length and usefulness of human life.

But we also see some sharp contrasts. At this moment, in some other city, a group may be meeting to consider how to provide air for the first human inhabitants of the moon. Yet, we are meeting here because we have not yet learned how to manage our lives without fouling the air that man must continue to breathe on Mother Earth. We hear of masterful schemes for using nuclear explosions to extract pure water from the moon; but in some American cities the water that flows from the tap is no longer an entirely palatable fluid, and the householder will find it instead in bottles on the market shelf. Science in 1962 is radiant with far-flung success, and—it would seem—clouded by growing difficulties in providing for the necessities of life.

Why should this be so? Is the pollution of the air that we breathe and of the water that we drink only a passing imperfection in human society? Or is it a more serious matter—a warning that despite all the new powers of science, or perhaps because of them, we can no longer exert a sufficient mastery of our environment?

Air pollution is only one of a number of new and unwelcome problems: the pollution of water, not only by human waste but also by synthetic chemicals; unwanted loss of animals and plants, and possible human health hazards from widespread dissemination of pesticides and herbicides; confusion about tolerable levels of chemical food addi-

tionships to science, and a troublesome involvement in public controversy.

(1) Each of these difficulties is a result of scientific and technological progress. The new synthetic chemicals, which are the fruits of remarkable advances in chemical technology since World War II, appear in a multitude of useful forms—but also as pollutants of air and water. The development, just 20 years ago, of self-sustained nuclear reactions has given us not only new weapons and sources of power—but radioactive debris as well.

(2) Many of these problems seem to crop up unexpectedly. The photochemical conversion of hydrocarbons, which produces smog, was discovered not in a chemical laboratory but in the air over Los Angeles, long after the technological practices that disseminated the hydrocarbons were well entrenched in our economic life. The resistance of synthetic detergents to bacterial degradation was apparently discovered only when the resultant accumulation in water supplies became noticeable, by which time detergents were already a common household item. The absorption of certain radioisotopes in the human body became known only some years after the establishment of massive programs of nuclear testing. All of these problems have been imposed on us—sometimes with a considerable surprise—well after the causative activity was in full swing.

(3) It is also characteristic of the pollution problem—whether of air, water, or food,—that the most serious difficulties arise in the realm of biology. Unfortunately, the processes which are the biological targets of modern pollutants are singularly intractable to scientific analysis. The hazards from certain air pollutants and from radioactive wastes are due to the possibility that they may induce cancers. The origin of cancerous growth and the mode of action of chemicals and radiation in promoting it remain, of course, one of the great unsolved problems of modern science. The mechanism of action of DDT on insects, and its effects in mammals, are poorly understood. Despite very considerable investigation, the basic mechanism of plant growth, with which the new synthetic herbicides interact, remains unknown.

There is, then, a remarkable incongruity between the two ways in which science enters into modern pollution problems. On the one hand, scientific pears to be poorly prepared to understand the particular biological damage that these new materials may cause.

The recent history of the sciences reveals some of the reasons for these conflicting consequences of scientific progress. Nuclear technology results from laboratory experiments on fission reactions first reported some 30 years ago; and behind this discovery lay the great revolution in our basic understanding of the structure of matter which took place at the turn of the century. One reason for the remarkable growth in the number of synthetic organic chemicals is that chemical engineering, which was once an empirical technology, has now become firmly based on the theoretical knowledge of the mechanisms of chemical reactions—which is in turn elucidated by the new physical theories.

While physics and chemistry and their technological offshoots have been radically reformed by the theoretical revolution that began about 50 years ago, biology—or at least those of its areas which are related to the effects of the new pollutants—has proven to be considerably more resistant to change. Anyone who wishes to be convinced of this need only compare the present textbooks of physics, chemistry, and biology with those of, let us say, 25 years ago. A 25-year-old text in organic chemistry is a densely packed summary of empirical knowledge about a vast array of organic reactions; but the modern text is a logically organized consideration of the electronic structures of atoms and molecules, and describes how this knowledge can guide the chemist in controlling reactions and in synthesizing new molecules to specification. On the other hand, current textbook discussions of the physiology of plant growth, or of the mechanism of carcinogenesis, while they may be couched in the language of present fads in experimentation, lead to the same final answer offered by a 25-year-old text: the mechanism of growth, whether of plants or of neoplasms, remains unknown.

If basic theories of physics had not attained their present power, we would not be confronted with massive dissemination of manmade radioactive isotopes and synthetic chemicals. If biological theory had by now become sufficiently advanced to master the problems of normal and neoplastic growth, we might be better prepared to cope with

these modern pollutants. We are in difficulty because of a wide disparity between the present state of the physical and biological sciences.

Trouble arises because the separation of the laws of Nature among the different sciences is, of course, a human conceit; Nature itself is an integrated whole. We classify nuclear explosions as experiments in physics, representing a step in a progression of growing knowledge about nuclear reactions. Yet every nuclear explosion is also a vast experiment in biology, but one which is only remotely connected with earlier biological research. Thus, modern physics was ready to detect strontium 90, to analyze its nuclear structure, and to understand its origin in the fission reaction. In contrast, modern biology was quite unprepared for the entry of strontium 90 on the scene, for until the fallout problem revealed the necessity for such studies, normal strontium metabolism was an almost completely neglected subject.

The same pattern can be found in most of our pollution problems. The development of highly efficient new insecticides reflects an impressive mastery of chemical synthesis and of methods of dissemination. But the intrusion of a new insecticide into the biosphere may lead to rude surprises.

The current debate about insecticides reminds me of my own education in this matter. During World War II, I served as project officer in the Navy's development of aircraft dispersal of DDT—which proved to be of great importance in the Pacific battles. The project made meticulous studies of aerosol production, aerodynamic distribution, insect kill, meteorological effects, and problems of flying tactics. Toward the end of our work, when we were justifiably proud of a system ready for fleet operations, we received a request for help from an experimental rocket station on a strip of island beach off the New Jersey coast. Urgent experimental work was severely hampered by flies; would the Navy please get rid of them? We doused the island with DDT. Within half a day the beach became a flyless paradise and the rocketeers went about their work with renewed vigor. But a week later they were on the telephone again. A mysterious epidemic had littered their beach with tons of decaying fish—and all the flies in New Jersey had come to enjoy the fun. That is how I learned that DDT kills fish.

I believe that the history of modern pollution problems shows that most of them result from the same general fault. We have been massively intervening in the natural world, without being aware of many of the biological consequences until the act has been performed, and its effects—which are difficult to understand, and sometimes irreversible—are upon us. We can produce and widely disseminate radioisotopes, but do not fully comprehend how they will affect life. We can synthesize and disseminate a marvelous variety of synthetic chemicals before we have sufficiently mastered what they will do in a living organism. Like that of the sorcerer's apprentice, our education is dangerously incomplete.

It will be argued, I know, that this is nothing new—that it is the grand purpose of science to move into unknown territory, to explore and to discover. It can be said that similar risks have been taken before, and that science and technology cannot move forward without taking some risks.

But these arguments overlook an important element which is new. In the past, the risks taken in the name of scientific progress—boiler explosions on the first riverboats, or the early experiments with X-rays—were restricted to a small place and a brief time. But the processes which we now strive to master are neither local nor brief in their effects. Air pollution covers vast urban areas. Fallout is worldwide. Synthetic chemicals may remain in the soil for years. Radioactive pollutants now in the biosphere will be found there for generations, and in the case of carbon 14 for thousands of years. The size and persistence of possible errors have grown with the expanding power of modern science.

One can also argue that the hazards of modern pollutants are small compared to the dangers associated with other human enterprises—such as automotive traffic. But no estimate of the actual harm that may be done by smog, fallout, or chemical residues can obscure the sober realization that the risk was taken before it was fully understood. The importance of these issues to science lies not so much in the technical difficulty of estimating the associated hazards, but in that they warn of an incipient abdication of one of the major duties of science—prediction and control of human interventions into nature. The true measure of the danger is not represented by the present hazard, but by the disasters that will surely be visited upon us if we dare to enter the new age of science that lies before us without repairing this basic fault in the scientific enterprise.

Having examined some of the scientific difficulties associated with modern pollution, what can be

public confusion and controversy, severe legislative debate, and enormous administrative difficulties. They represent a veritable jungle in which science, industry, economics, local politics, foreign affairs, religion, and morality intermix in uproarious confusion. No scientist who enjoys the quiet of his laboratory or the reasonableness and objectivity of scientific discourse is likely to walk into this wilderness voluntarily—or to emerge from it unscathed.

That thousands of scientists—including those present at this conference—have been willing to devote their skill and energy to bring order out of this chaos reflects, I believe, the serious impact which these problems have had on the inner life of science.

In no area has there been a more serious concentration of effort than in the problem of low-level radiation from fallout, particularly under the aegis of the U.S. Public Health Service. The recent history of this issue provides a clear picture of how the social problems emerge from scientific ones and can illuminate some general aspects of environmental pollution as a whole.

Until a few years ago the possible effects of low-level radiation were guided by the assumption that doses below a particular level would cause no discernible medical effects. Since the estimation of the threshold dose is a purely scientific matter, it was possible for groups of scientists, such as the International Committee for Radiation Protection, to deliberate on the problem and recommend some permissible level of radiation which ought not to be exceeded if medical hazard is to be avoided.

However, evidence has since accumulated which suggests that one cannot safely assume any threshold in the relationship between radiation dosage and the resultant biological effects. Consequently, beginning in 1958, scientific agencies charged with the responsibility of setting radiation protection standards uniformly adopted the assumption that any increment in radiation exposure, however slight, is accompanied by a comparable increase in the risk of medically undesirable effects. If this is the case, and there is no absolutely safe limit, how can one determine what dosage is to be tolerated?

This judgment requires a balance between the risk associated with a given dosage and some possibly countervailing benefit. The agency now responsible for setting radiation standards in the

> regard to radiation protection, the resulting biological risk might well be considered too great. Reducing the risk to zero would virtually eliminate any radiation use, and result in the loss of all possible benefits. It is therefore necessary to strike some balance between maximum use and zero risk. In establishing radiation protection standards, the balancing of risk and benefit is a decision involving medical, social, economic, political, and other factors. Such a balance cannot be made on the basis of a precise mathematical formula but must be a matter of informed judgment.[1]

This approach is, I believe, equally applicable to most other pollution problems. Since they are all large-scale effects and influence a wide variety of living organisms, on statistical grounds alone, it is probable that the smallest detectable pollutant level represents some hazard, however slight, and that the risk will increase roughly with the level.

What is the proper role of the scientist in such a judgment? What scientific procedure can determine, for example, whether the benefits to the national interest of nuclear testing outweigh the hazards of fallout? What is the "importance" of fallout, determined scientifically? Some scientists have stated, with the full dignity of their scientific preeminence, that the fallout hazard while not zero is "trivial." Nevertheless I have seen a minister, upon learning for the first time that acts deliberately performed by his own nation were possibly endangering a few lives in distant lands and a future time, became so incensed at this violation of the Biblical injunction against the poisoning of wells as to make immediate determination to oppose nuclear testing. What science can gage the relative validity of these conflicting responses to the same facts?

How can scientific method determine whether the proponents of urban superhighways or those who complain about the resultant smog are in the right? What scientific principle can tell us how to make the choice—forced upon us by the insecticide problem—between the shade of the elm tree and the song of the robin?

Stated in this form, the answers to these questions become apparent. Certainly science can validly describe what is known about the information to be gained from a nuclear experiment, the

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[1] Report No. 1, Federal Radiation Council, May 13, 1960.

economic value of a highway, or the hazard of radioactive contamination or of smog. The statement will usually be hedged with uncertainty, and the proper answer may sometimes be: "We don't know"; but in any case these separate questions do belong within the realm of science. However, the choice of the balance point between benefit and hazard is a value judgment; it is based on ideas of social good, on morality or religion—not on science.

There can be no scientific agreement on such judgments; answers will differ according to religious or political outlook. Scientists who present their own judgments on these matters as though they were scientific evaluations are simply forcing a disagreement which can never be resolved by scientific means. Such a disagreement appears as a perplexing exception to scientists' vaunted skill at winning truth. The citizen will be driven to ask a question which is now heard with increasing frequency, "How do we know which scientist is telling the truth?" This doubt can only impair confidence in the validity of the excellent methods which science possesses for getting at the truth—about scientific questions.

In the "informed judgment" of which the Federal Radiation Council so properly speaks, the scientist can justly claim to be "informed," but in my opinion he can make no valid claim for a special competence in "judgment." To act otherwise is to corrupt the meaning of science and to undermine its usefulness to society.

I believe that once the scientific evidence has been stated, or its absence made clear, the establishment of a level of tolerance for a modern pollutant is a social problem and must be resolved by social processes. In these processes the scientist has one vote and no claim to leadership beyond that given to any person who has the gift of moving his fellow men. But the government official, whose task is to make these judgments, and the citizen—who must provide the social ideology which guides administrative decision—require for these purposes the necessary facts, and the relevant evaluations. Where these are matters of science, the scientist as the custodian of this knowledge has a profound duty to impart as much of it as he can to his fellow citizens. But in doing so he must guard against false pretensions, and avoid claiming for science that which belongs to the conscience.

In this discussion I have tried to show that the scientific and social difficulties that encumber the problems of modern pollution reflect a basic flaw in the present relations between science and social processes. We have not yet learned how to apply modern science in a manner which is consistent with its enormous power and its present inadequacies. We have not yet learned to discern in these complex problems the proper roles of scientific knowledge and social judgment.

It seems to me that until effective means for dealing with these questions are developed, we will be in continuous danger from unanticipated and poorly understood hazards, which will grow in magnitude as the power of science advances. If we are to live securely with the new discoveries and inventions of modern science, we shall need as well new inventions to govern the relation between science and society.

Although the task of developing such new procedures is formidable, there are some useful guidelines in our recent experience. I believe, for example, that the scientific community might have done a great deal to mitigate the present conflicts about insecticides, fallout, and smog, if it had applied the customary principles of scientific inquiry to these problems at the right time. Clearly, the decisive time to evaluate the risks associated with a new technological program is before it is put into effect. The longer such an evaluation is delayed, the less its value to society, for once the process has become embedded in a vast economic or political commitment, it may be nearly impossible to alter.

In this task, the scientist's duty is plain, for it is no different from his responsibilities toward the development of all scientific knowledge. The scientists must examine all the evidence and summarize it in a statement of what is known, what is assumed, what is doubtful, and what is possibly erroneous. He must also describe the limits of the relevant knowledge, for these will reveal what new knowledge is needed and indicate when a proposed technological application may expose us to the dangers of acting in ignorance.

I make this proposal quite conscious of the obstacles which may block scientific evaluation of risks and benefits *in advance* of a proposed technological innovation. Perhaps the most serious of these is that the government's military or political necessities, or an industry's competitive position, may dictate secrecy. A recent scholarly review on the toxicology of herbicides, written to enlighten the scientific community and to encourage new work on this difficult problem states in its opening paragraph: "Many of the toxicological data underlying

authorities concerned. Such data have not been included in the present survey." [2]

We pay a steep price for this kind of secrecy. Scientific knowledge is not created whole in one man's mind, or even in the deliberations of a committee. Each separate scientific analysis yields an approximate result and inevitably contains some errors and omissions. Science gets at the truth by a continuous process of self-correction, which remedies omission and corrects errors. In this process, the key elements are open disclosure of results, their general dissemination in the community of scientists, and the resultant verification, criticism, and correction. Anything that blocks this process will hamper the approach to the truth. The basic difficulty with secrecy in science is that mistakes made in secret will persist. Every attempt to keep a scientific problem secret is paid for in the most expensive currency in the world—knowledge.

Science has great power to serve society. But it cannot properly perform this function if deprived of access to the facts. The time has come, I believe, for government and industry alike to consider with great care the relative benefits and risks associated with the avoidance of full and early disclosure of scientific evidence relevant to large-scale processes that may result in environmental pollution. I believe that the present confusion and controversy about these problems are part of the price paid for secrecy, and in my opinion the price is uneconomical for industry and the Nation alike.

It should be possible, I believe, to find ways of bringing the full force of scientific knowledge—which is something that only the total community of scientists possesses—to bear on these problems. An important first step might be the organization, *in advance* of any large-scale technological innovation of an open *Scientific Inquiry* to consider the state of knowledge about the associated benefits and hazards. This, or any other, procedure must be established soon, for new proposals are being advanced constantly. Suggestions have been made for the use of mutagenic (and therefore also carcinogenic) chemicals for controlling insects by inducing sterilization. This may entail new biological hazards. Surely the scientific community can ar-

[2] Pharmacological Reviews, 14: No. 2, June 1962.

sideration of the problems of environmental pollution, they will have a much wider usefulness. Consider, for example, a proposal which is about to be considered by the Government to develop airliners designed to fly at two or three times the speed of sound. Such an airliner flying across the United States will produce in a zone 25 miles wide a continuous series of intense sonic booms. Where in our social processes have we weighed whatever benefit is involved in traveling from coast to coast in 2 hours against the hazards associated with the effects of sonic booms?

I can report that in my own city the resolution of this balance has taken a rather curious form. For a period of weeks earlier this year, St. Louis endured sonic booms, sometimes at hourly intervals and often in the small hours of the night. The hazards were clear: the Air Force was besieged with claims for broken windows, cracked walls, and fallen ceilings. Citizens complained about children awakened or frightened while awake. Protests began to mount, but not enough to counterbalance the military benefits of the flights—for they continued. I offer as a possibly useful piece of evidence regarding the weight to be accorded such benefits and hazards that when two gazelles in the St. Louis Zoo became so startled one night as to die in the ensuing upset—the flights were abruptly halted.

Is this the proper measure of the sonic boom hazard? Do we know enough about the number of babies that will be awakened every night by a supersonic airliner to make an "informed judgment" on its social usefulness? Do we really understand the physiological effects of the rather sudden compression associated with a sonic boom to be capable of evaluating the basic medical hazard? If these factors are not yet understood, how can a government agency, or the citizen, make the necessary informed judgment? If we invest nearly $1 billion in an airliner before we have determined whether its social usefulness will outweigh its social harm, will the step become thereby an irreversible one? Surely we need a scientific inquiry into this project before it is committed to action.

But no amount of advance information will suffice if it is not in the hands of those who must serve as the final arbiters of social good—the citizens. Can this be done? Can we expect our citizens to comprehend the benefits and hazards of nuclear

reactions? Can they understand the relationship between hydrocarbons, sunlight, and smog?

I am convinced that this is possible—providing citizens accept the duty to learn, and scientists accept the duty to teach. The task will not be an easy one, but I believe that we have the resources at hand. This vast educational task is not one that ought to be delegated alone to those scientists who have already devoted their professional energies to the problems of environmental pollution. These problems are so large and range so widely across the spectrum of science, that all scientists, regardless of their immediate professional interests, are intimately concerned with them. Pollution of the environment touches the work of every meteorologist, ecologist, or chemist; the possible hazards are of interest to every biochemist and to every specialist in the biological and medical sciences.

Knowledge of these problems, and the willingness to explain them to the public, should, I believe, be the responsibility of each of the more than 100,000 scientists of this Nation. Given this army of teachers, which is available to almost every community in the country, this educational task can surely be accomplished. Already in a number of cities, groups of scientists are educating their fellow citizens about radiation problems; I believe that given adequate support and the broad participation of all scientists, such groups should be capable of expanding their work to encompass the broad range of problems of environmental pollution.

Nor should we be discouraged by the difficulties and disagreements that now burden these problems. The attention which these controversies generate can serve as a timely warning that we must learn—now, before the hazards of unwitting action overtake us—how to live in the new world that science is creating. Science has placed enormous new powers at the hand of man. If we accept with these powers the new responsibilities which must govern their use, science can serve its true goal—the welfare of man.

INDUSTRIAL STATESMANSHIP IN AIR POLLUTION CONTROL

JERRY McAFEE
Vice President
Gulf Oil Corp.
Pittsburgh, Pa.

Having had the privilege of serving as one of the petroleum industry's representatives at the 1958 National Conference on Air Pollution, I am particularly pleased to be able to speak today from the somewhat broader standpoint of industry in general.

What I shall say is entirely my own responsibility; I am not speaking officially on behalf of any industrial group. I have reason to believe, however, that the thoughts I shall try to express are shared by a substantial segment of American industry.

In many previous discussions the point has been ably developed that our atmosphere is a precious asset with a large but finite capacity for supporting life and for absorbing many of the waste products of our accelerating civilization. Undoubtedly at this conference there will be presented for consideration much additional information concerning the demands now placed on the atmosphere as a waste receiver and the rapid increases in these demands which are likely in the future.

There can be no effective denial of the fact that achieving optimum use of this vital asset—the atmosphere—is a matter of grave and vital concern to the Nation. Indeed, in this day of space exploration, rapid communication, and nuclear development, limitation or wanton misuse of our air resources has truly international aspects.

Nor can anyone seriously question the fact that responsibility for striving toward optimum use of this valuable natural resource rests inescapably upon all of us, whether we be government representatives, scientists, industrial people, or just individual private citizens—as of course we all are. No useful purpose is served by finger pointing, name calling, or blame fixing. Rather, it is up to each of us as individuals or as members of one or more groups concerned to assume our fair share of the responsibility for "keeping our nest clean" and appropriately assisting and encouraging others to do likewise. As aptly put by the Engineers Joint Council, "Our common goal is to maintain a reasonable degree of purity of our air consistent with: (*a*) the public health and welfare and public enjoyment thereof, (*b*) the continued industrial development of our country, (*c*) the protection of plant and animal life, and (*d*) the protection of physical property and other resources."

It is entirely fitting that a portion of the first day of this important conference should be devoted to reviewing the responsibilities of several segments of our society with respect to air utilization. Perhaps from this consideration can come a little better appreciation of the goals, the problems, and the needs of these groups, with the result that our efforts toward achieving optimum use of the air will be more effective, better coordinated, and ultimately more successful. To the extent this objective is achieved, our time and effort today will have been well spent.

Industrial Accomplishments

It is a temptation to use the time which has been allotted to me in enumerating the strides which have been taken—especially in recent years—by industry in general and by certain industries in particular in combating air pollution. But everyone with enough interest in air pollution abatement to be present today must be at least quali-

tatively aware of the millions and millions of dollars which have been spent by industry for air pollution control facilities. You recognize, of course, that while there are instances in which air pollution abatement equipment pays its way by recovery of materials which would otherwise be lost, frequently such facilities are without economic justification and therefore their cost must ultimately be borne by the consumer. You know something of the tremendous expenditures and efforts devoted by many companies and industrial groups to research directed not only toward developing methods for controlling their own operations so as to avoid giving unnecessary offense but also toward providing the users of industrial products with the understanding and equipment necessary for their lawful and considerate use. And you are undoubtedly aware of the contributions of members of the industrial community to the endeavors of such organizations as the Air Pollution Control Association, the American Institute of Chemical Engineers, the American Society of Mechanical Engineers, the Engineers' Joint Council, and others which are concerned in part with the development and dissemination of information relating to air pollution control and abatement. Furthermore, many of these accomplishments by industry will be covered in some detail in other sessions of this conference.

Accordingly, it seems to me that our time this afternoon might best be spent in examining some of the responsibilities which necessarily fall on the shoulders of industrial management and in setting forth some guidelines which I believe may be helpful in meeting these responsibilities as they pertain to air pollution control.

The nature of modern industry is such that management clearly and properly is responsible to at least three groups: the stockholders, the employees, and the community. The inherently different interests of these groups lead to a diversity of sometimes opposing forces and pressures which seek to influence management decisions. Very briefly, let us explore some aspects of these areas of management responsibility and the forces they generate.

Management's Responsibilities to Stockholders

Industrial management's most obvious responsibility is to the stockholders, the people who have invested their savings in the business in the confident and wholesome expectation of earning an appropriate return. Sometimes these stockholders are the manager himself and maybe a few close associates or members of his family. But more commonly the shareholders, the real owners of our companies and the people whom the president, the vice presidents, and all levels of management really work for, are thousands upon thousands of owners who rely upon the professional managers they employ to operate the business in their behalf.

Management's first and clearest duty to the shareholders is to see to it that the business earns an adequate profit in order to provide the funds for modernization and expansion, and to permit the payment of dividends which will compensate the investors for the use of their money. This means minimizing costs, eliminating waste, avoiding unnecessary capital and operating expense, increasing efficiency by installation of cost-saving equipment, adopting new techniques of production and distribution, and the myriad other steps which are essential to profitable operation in this fiercely competitive world we live in.

But a broader, longer range, and less obvious duty is also involved: to insure the perpetuation of the business, to make certain that the shareholders' interests will be protected not only now but in the future, and that the enterprise in which they have invested will be a continuing source of adequate return. Obviously this requires alert attention and response to changing conditions, willingness to adopt new developments, intelligent diversification, and aggressive expansion. It also involves carefully nurturing the public acceptance of the industry and its products and, conversely, avoiding those practices and policies which might lead to public censure as expressed either in the marketplace or through legal channels.

So far as air pollution abatement is concerned, in discharging its responsibility to the owners, management is necessarily torn between two opposing forces. On the one hand, all unnecessary costs must be avoided; but, on the other, those expenditures which are essential to the long-term operability of the plant and acceptability of the product must be made. A plant manager who, in his zeal to produce maximum immediate profits, allowed his plant to become such a nuisance as to risk its being shut down as a result of public opinion or legal requirements, would not have served his shareholders well. But equally unfortunate would be the case of the manager who was so carried away by his enthusiasm to adopt the newest air pollution control methods and equipment, whether needed or not, that his plant suffered competitively and eventually had to

To Employees

Management also has significant and clearly recognized responsibilities to the employees—those men and women who, whether or not they also may have invested their savings in the enterprise, are contributing their brains and muscles and skills to it. These responsibilities obviously include appropriate compensation in accordance with the work done, satisfactory working conditions, adequate safety precautions, and many so-called "fringe benefits."

But management's larger responsibilities to the employees as well as to the shareholders must necessarily also include making a profit and perpetuating the business. The long-range best interests of the employees are not served by misguided overemphasis of employee benefits and comfortable working conditions which could result in a noncompetitive, uneconomic, and eventually closed plant.

Again relating these generalities to air pollution abatement, management certainly has an obligation to make sure that its employees are not subjected to health hazards resulting from airborne wastes and that their effectiveness is not impaired either on or off the job by excessive air contamination in and around the plant. But, with equal force, the real interests of the employees as well as the shareholders demand that all unnecessary and unwarranted expense be avoided. An absolutely clean, smokeless, odorless plant might be a pleasant place to work; but this pleasure would be fleeting and illusory if the price of such excessive cleanliness were the profitability of the enterprise or its ability to compete effectively.

To the Community

To an increasing extent in recent years, it has been recognized that industry and industrial management carry substantial responsibilities with respect to the communities in which they operate. Today responsible management generally realizes that its own enlightened self-interest, if nothing else, demands that the needs and sensibilities of the community be respected.

When it comes to air pollution, industry is keenly aware that there are limits beyond which the waste-absorbing capacity of a given community's demonstrating its readiness to take the necessary corrective steps—provided, of course, that technically sound and economically feasible control methods are available.

But there is another side to this coin also: a community which insists on too rigorous air pollution control; imposes too stringent air quality standards; or sets up and tries to administer an unfair, discriminatory, or confiscatory air pollution control program, in the long run harms itself. I can assure you from personal experience that it is not just idle talk that industries do very definitely assess the air pollution control policies of a community, among other factors, before deciding on the location of a new plant or the expansion of an existing one. There *is* a happy medium between too much control and too little, just as there is between too much expenditure for air pollution abatement and too little. It is in the community's best interest, as well as that of the shareholders and the employees, to find this optimum.

Industrial Statesmanship

From the foregoing, necessarily sketchy review of some of industrial management's inescapable responsibilities to the shareholders, to the employees, and to the communities in which the industry operates, I hope it is apparent that opposing forces are constantly at work—some pulling in this direction, some in that—tending to influence the decisions of management regarding air pollution abatement as well as other matters. I submit that industrial statesmanship in air pollution control comprises balancing these forces in the best interests of the several groups to which management has responsibility: shareholders, employees, and the community. It should not be surprising to anyone when, in the field of air pollution as in other areas, the long-range good of all requires a sacrifice of the present preferences of some.

Clearly a great deal of individual judgment is involved and, since we are all individuals, our judgments will frequently differ. It falls upon all of us, therefore, in considering what should be done with respect to any given air pollution situation to remember that there are always counterbalancing forces which may be equally as important as those we are most acutely aware of. We need to remem-

ber also that there is room for honest differences of opinion as to which forces deserve the greatest response at any given time.

Guidelines

In striving toward this statesmanlike balancing of opposing forces and in seeking optimum use of our air resources, consideration of the following simple but important guidelines may be helpful.

1. *Be sure there is a real problem.* This complex and troubled world we live in is so full of significant, pressing, and perplexing problems that we can ill afford the luxury of wasting effort on imaginary problems or trying to discover problems where none exist. Let us avoid the temptation to assume that because one industry or one community has a certain air pollution problem, other industries and other communities are also faced with the same problem. We need always to remember that communities vary widely in their topography, their meteorology, their degree of industrialization, and other factors, and that circumstances which might lead to an intolerable condition in one locality could be entirely harmless and acceptable in another. Because human health is of such vital personal concern to each of us that we are naturally inclined to get emotional about it, we should be particularly cautious in ascribing or assuming a cause-and-effect relationship between air pollution and health until scientifically reliable supporting evidence is available.

2. *Make certain that we know what the problem really is.* Even when there is clear evidence that a problem exists, its true nature is sometimes far from clear. Embarking on control or abatement programs before the objective is well defined is both costly and ineffective, as demonstrated by a number of classic and well-known "false starts" in air pollution control.

3. *Be sure that technically sound, economically feasible, and effective methods for solving the problem are available.* Passing laws and issuing regulations will do no good unless and until effective means to comply with them are at hand. Sometimes such means are already known and only dissemination of them is required. In many other cases, more research and development are necessary, responsibility for which can sometimes be appropriately shared between government and industry.

4. *Use explanation, education, and persuasion to the fullest before resorting to compulsion.* Most people, most industries, most communities will respond favorably when a real need is pointed out to them and when effective means for meeting the need are available. Such voluntary cooperation is often more intelligent and, therefore, more truly effective than blind compliance with even the most carefully written regulations.

5. *If compulsory measures are necessary, be sure they are fairly devised and fairly administered.* Regulations which unfairly discriminate between industries or activities have no place in an intelligent attack on any community's air pollution problems. While intentional damage is undoubtedly rare, it is highly desirable that the necessary time and study be devoted to the matter to make certain that no harm, either intentional or unintentional, is done to any individual or group unless it is required by the common good.

6. *Keep control measures and their enforcement as local as possible.* Communities and areas differ so greatly in their needs and resources that broad, general, all-embracing regulations on a nationwide or sometimes even a statewide basis are almost certain to be too stringent for some localities and not strict enough for others. Indeed, standards which are appropriate for one city may actually be harmful for another. Furthermore, in a nation as vast as ours, no central agency can possibly be as effective in dealing with local problems as those who are intimately familiar and concerned with them. The overall national good, as well as the best interests of the local community, are best served, I believe, by letting each local area subject to the same group of pollution sources make its own determination of what air pollution regulations are necessary and appropriate for it. This does not mean that State and Federal agencies do not have an important role to play in the air pollution field: conducting research, providing technical assistance, offering training, assisting local groups in conducting studies and surveys, and the like. It does mean leaving the control

a heavy responsibility to make certain that controls are not extended for their own sake or because air pollution control is "fashionable."

While the above thoughts could undoubtedly be expressed more eloquently and in many different ways, I believe the principles underlying them are sound and deserve our continuing consideration.

alone cannot solve them. Industry is determined to do all it can to be sure that its efforts and its money are employed effectively toward the solution of real problems; and it will strive with equal vigor to avoid unnecessary and ineffective expenditures. This willingness to cooperate, coupled with this determination to be effective is, I believe, the essence of industrial statesmanship in air pollution control.

POLITICAL STATESMANSHIP

HARRISON A. WILLIAMS
U.S. Senator
Westfield, N.J.

It is a pleasure to be here with you today to discuss the problem of air pollution.

In thinking about the subject of "Political Statesmanship," I was struck with the thought that the theme of this conference—"Let's Clear the Air"—may have a double significance.

For one thing, it strikes me that there is a scope to the theme that is important and appropriate for the wealthiest nation on earth in mid-20th century.

"Let's Clear the Air." Not just because it is now a definite health problem and may be a most serious health hazard in the future. And not just because air pollution causes tremendous economic damages—amounting to billions of dollars a year—to industry, agriculture, the community, and the individual.

I think we ought to clear the air if only because it sometimes smells bad, it too often robs us of seeing the full beauty of a sunset, and in general constitutes a blight that mocks our efforts to achieve a safe, decent, and attractive living environment for a large majority of the American people.

Perhaps there are some who would disagree with my idea that the goal of air pollution control should be so sweeping that it should embrace more or less esthetic as well as health considerations.

But I think one illustration will serve to make my point. I am told that the fumes from a diesel bus, which I am sure we have all experienced, are far less of a threat to health than the exhaust from an automobile.

Yet how can we entertain the notion of achieving a genuinely civilized urban environment without somehow controlling the obnoxious belching of the bus exhaust?

So I think the scope implicit in the theme of the conference is a significant one. I hope it will lead to agreement on the importance of waging total war against air pollution, until it is no longer either harmful or annoying.

* * * * *

The theme is also significant from another standpoint.

I think that before we can hope to clear the air around us, we first have to clear the air in our discussion of the problem. Which brings me to the subject of my talk.

It seems to me that an essential part of political statesmanship is the willingness to face and meet the real issue honestly.

Yet from my limited perspective, I can't help wondering whether there isn't more smog shrouding the real issues of air pollution than there is smog covering most of our cities.

I think this state of affairs can be attributed to a lack of sufficient political statesmanship in facing the real issues.

And when I speak of "Political Statesmanship," I am not limiting it to the role that has been played by public officials at the Federal, State, or local level.

The challenge of political statesmanship faces every individual and every organization involved and interested in the problem.

It even faces this conference. Certainly it is no secret that any conference, no matter how noble its objectives, can turn out a failure if the participants leave under the impression that progress has been made by simply talking about the need for it.

I think this conference has the goal of finding not how much we have yet to learn about the problem, but how much and what we should be doing in

And by setting out the courses of action that are needed, you would also help others face the issue more squarely. And that goes for us in Congress.

I stress this because I am afraid we have perhaps seen as much gamesmanship as statesmanship in the efforts to help clear up the air.

Research, of course, is one of the favorite tools in the practice of political gamesmanship.

This is not to say that research is not important, especially in this field where research could lead to important technological breakthroughs in the creation of more economical pollution control devices.

But research is worthless unless it is accompanied by a desire and a determination to translate the fruits of it into action.

Research somehow has a way of becoming an end in itself, and of course those who really don't want to face the hard issues of taking action can always think up endless questions that deserve further study.

For example, there are those who think it is very important to study the question of when air is polluted and when it can be considered pure. After all, we pollute the air every time we smoke a cigarette.

Certainly we need some kind of standards here, but we have so far to go in bringing pollution under satisfactory control that the question of whether or not we may eventually be engaging in needless effort is one that is less than urgent in my scheme of priorities.

Then there is the closely related question of determining the exact amount of economic damage caused by pollution so that we don't end up spending more to control the problem than the problem is costing in damage.

Again, this question is far from critical inasmuch as the damage from air pollution is estimated at more than $7 billion, while the Federal Government is spending some $11 million a year and industry perhaps several hundred million.

Another favorite sport seems to be the search for the final percentage.

I remember a committee report that made a strong statement that the Federal Government ought to be doing more to determine—and I quote—"the part that motor vehicle exhaust and is substantial and that we have a long way to go in actually coping with it.

This year the Congress amended the Air Pollution Act, and made special reference to the automobile exhaust problem, directing the Surgeon General to conduct "Studies of the amounts and kinds of substances discharged from the exhausts of motor vehicles and of the effects of the discharge of such substances. . . ."

But it seems to me that this kind of research is considerably less important than undertaking research to find economic methods and devices for preventing or controlling the pollution we know comes from vehicle exhausts.

Other than adding this paragraph, the only thing Congress did this year in air pollution was to extend for 2 years the life of the basic act, which was scheduled to expire in 1964.

And of course the basic act, approved in 1955, is simply a research program.

In 1958, the Department of Health, Education, and Welfare sponsored the first National Conference on Air Pollution which involved people other than just those working at the professional and technical levels. The goals of this conference were listed as assessing the existing state of knowledge, and determining future goals.

Then in 1960 we saw the report of the Surgeon General's task group on air pollution. (No doubt the task group was a prototype for what we now like to call a task force.) This group listed some 10 national goals that ought to be accomplished in the decade of the sixties. All of these goals, by the way, were in the field of research. The first goal was "To Determine the Effects of Air Pollution on Human Health."

I must confess that I was struck by the announcement of this goal, for up until then I had been unaware that air pollution had any good effects on human health.

But more to the point, I think our goal ought to be the elimination of air pollution by the end of the sixties, and not just the elimination of our ignorance about the problem.

We have been trying to eliminate our ignorance for the last 6 or 7 years now, and we have yet to fully face the fundamental issues—which are money and the enforcement of air pollution control.

There is no question but that further research would more clearly identify the most serious sources of pollution and provide more economical ways of controlling the pollution, but at some point action must begin, and money must be spent.

I think it is equally clear that if effective action is ever going to be taken, the Federal Government is going to have to exercise far greater leadership than it has so far—if for no other reason than the fact that most States have serious financial problems and are often vulnerable to threats by an air polluting industry to move somewhere else where, as they say, the public officials are "more understanding."

It seems to me that the bills introduced this year by Senator Engle and Representative Rhodes of Pennsylvania represent a good start toward the goal of clearing up the air. Among other things, they specifically declare that the Federal Government has "an obligation to provide the leadership in the initiation of national programs of research and development necessary to the ultimate prevention and control of air pollution," and they direct the Secretary to "mount a concentrated national effort to achieve the prevention and control of air pollution within the next 10 years."

The legislation provides financial assistance to air pollution control agencies for the development or improvement of their actual enforcement programs, in contrast to the existing law, which provides assistance only for abatement research programs.

The bills also include a provision authorizing the Federal Government to call a public conference, at the request of a State or on its own initiative under certain circumstances.

Incidentally, I was very sorry to see that a similar provision was dropped from the legislation enacted this year. Inasmuch as the recommendations resulting from a public hearing or conference were not binding on anyone, this was the least we could have done.

Personally, I think that enforcement procedures will eventually have to be enacted along the lines proposed by Senator Neuberger, in her bill which I had the pleasure of cosponsoring. These enforcement procedures, as I understand them, would be roughly similar to those followed under the existing water pollution program.

I only hope that we will not have to have a thalidomide incident in the field of air pollution to stimulate Congress into taking appropriate action.

I don't think it is necessary to add, however, that any enforcement program would have to be administered with discretion in view of the changing state of technological development, the unusual costs that may be involved when measured against the effectiveness of the control device, and so forth.

Another area I hope this conference will devote its attention to would be the feasibility of providing financial assistance, in perhaps special circumstances, for the actual construction of pollution control facilities. This also was a feature of the Neuberger bill.

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Just from this brief description, it is clear that a variety of ideas have been proposed as possible approaches to the task of clearing up our air.

I hope this conference will help crystallize the thinking of public officials, organizations, and individuals so that a feasible and effective course of action can be developed and pursued.

I suppose at this point it would be appropriate to make a bow to the need to arouse public interest in and concern over the problem of air pollution.

This is undoubtedly important, but I also think that in the field of air pollution we will be waiting in vain if we expect that this or any other conference will result in a march on Washington by legions of citizens waving "Let's Clear the Air" placards in their hands.

In looking over the proceedings of the 1958 conference, I was struck by the remarks of Dr. Herman Hilleboe, Commissioner of the New York State Department of Health, who said that the first thing wise elective officials do is "to sell their program goals by informing their constituents that a problem exists and explaining how they propose to solve it. Then they wait for public reaction. If the reaction is mostly silence, they know that they have succeeded in selling their plan."

As Dr. Hilleboe correctly points out, we are dealing with "a busy, on-the-go species of homo sapiens which holds the joint world's record for having the most informed opinions and the least time to do anything about them."

Therefore, leadership is absolutely essential by all interested parties, above all by the executive branch of the Government.

I earnestly hope everyone interested in clearing the air will press hard for the enactment of effective legislation.

And this coming year is none too soon to start.

DISCUSSION

Edmond Huntzbuchler. In his study of "Air Pollution in Europe," Mr. Arthur Stern reaches the following conclusion:

> The air of European metropolises tends to be more visibly polluted than that of comparable American cities. In America, the results of work in all States are rapidly disseminated at frequent conferences and seminars, whereas in Europe, interchange of information is impeded by language and political barriers that tend to dilute the large total effort by requiring each nation to duplicate much of the same work.

These same reasons moved the Consultative Assembly to recommend that the Committee of Ministers of the Council of Europe should convene a European Conference on Air Pollution.

The Committee of Ministers of the Council of Europe has accepted the Assembly's suggestion, and the European Conference on Air Pollution will be held in 1963, the first of its kind in Europe. It will be of the same character as the Washington conference, defined as follows by Mr. Stern in the letter of invitation sent to the Council of Europe:

> It will not be a technical, scientific seminar. We plan rather to have a program that will present information of importance to the general public, as well as to scientists, engineers, physicians, and others with a technical interest in air pollution.

Europe has from the start realized the advantage of close collaboration with the United States in the matter of air pollution. Not only has the Council of Europe studied the documentation received from the United States, but also, the list of participants proposed by the Assembly Recommendation specifically mentions the Surgeon General of the Public Health Service.

The Council of Europe would be happy if other leading American figures were willing to attend the conference, which would benefit greatly from their expertise. All those competent in the matter in Europe are convinced that permanent collaboration between the two continents would be invaluable and the Council of Europe would be most grateful to all American experts and authorities prepared to encourage such collaboration and to assist the Council of Europe in its work.

A true partnership might thus be established between Europe and America in a field of prime importance to the health and well-being of humanity.

* * * * *

On behalf of the Council of Europe I should like to extend an invitation to those Americans who are ready to participate to our conference.

Daniel W. Cannon. Senator Williams, most of the speakers here today have stressed the fact that control programs should be located within the local community and there has even been a reference by Secretary Celebrezze to some of the accomplishments in Cleveland when he was mayor of that city. There have also been numerous references to successful achievements in other cities such as Pittsburgh, and I might mention that the National Association of Manufacturers, which I represent, has an exhibit booth downstairs at which we're distributing the story of Pittsburgh, "Cinderella City." With such unanimity here, except for your statement, I was puzzled by your remark to the effect that Federal enforcement legislation was inevitable or was down the road for some time in the future.

Williams. The kind of enforcement program I had in mind comes after the community control program. I am far from expert on the art of air pollution control, but I certainly don't think the enforcement program should be the cart before the control horse. I suggest that control at the local level is all right if the control runs through the entire community that shares the pollution. I don't see any advantage to the State of New Jersey in a magnificent program of control and effective control enforcement if Staten Island, 200 yards away, isn't a partner in a similar program. When the east wind comes, we're right back where we started from. The only good thing we get from over that way, I think, is the smell of Hershey chocolate. I would accept the idea of community control if it also protects another community that shares the pollution. Does that make sense?

Cannon. In Pittsburgh, they found it necessary to get the entire county, comprised of about 180 communities, working together in order to achieve this, but it still seems to indicate that this can be done on a countywide basis or by an interstate compact arrangement, without having remote centralized control from Washington.

Williams. I think we do need some Federal stimulation here, in this field as in others, and I tried to give the reasons at the outset. In the field of health, we know that in the last decade or so—and here, Congressman John Fogarty can not only share, but even claim, responsibility—we have found it necessary to put problems of health in a highly impor-

tant position at the national level because they were being pretty much overlooked farther down the line. I also support the National Institutes of Health. I think that a program for cleaning the air would be a natural ally of the National Institutes, of which I am very proud. I'm going to bring you into this, John. Aren't you proud, too?

Fogarty. Yes, sir.

Samuel S. Johnson. My question is similar to Mr. Cannon's. I felt that all of the speakers this morning, with the exception of Senator Williams, indicated quite clearly that local and State control was the most effective means of air pollution control. Many of us are very fearful of the Federal Government beginning, as the Senator says, a stimulating action. Stimulating to me indicates a temporary status. It's very seldom that the Federal Government stops stimulating, once they start stimulating.

Williams. Where would you have us stop stimulating?

Johnson. With the rapid developments that have taken place in the last few years and with the growing public awareness of the problem—by the average citizen of Los Angeles and of other communities—I think the local people are going to take some steps. Industry has spent millions and so have the local communities. I feel this is not the right time for the Federal Government to step in with a bill like the Neuberger bill, which supersedes everything that has been done. I feel that the proper position of the Federal Government at this time, and perhaps for a year or so to come, is to stand by and see what action the local communities take, now that the general public is becoming more aware of this serious problem.

Williams. There's an airline pilot in the audience who spoke to me during the recess, and he describes the national scope of air pollution more dramatically than I could. He flies long distances at high speeds and he describes the layer of pollution that he sees on his long traverses across the country. He told me that he hasn't spoken yet, but maybe he will say something. Where is Captain Guthrie?

W. L. Guthrie. I was indeed alarmed at the tenor of some of the speakers today, in that local control was spoken of repeatedly. Now, suppose you were making an approach to Detroit, with the winds from the southwest. It would be an instrument approach and you could see as far as your hand in front of your face perhaps, and this would be spoken of as Detroit's dirt. This is not true. The ambient air, the air being breathed by the Detroiters at that time, came from Chicago, South Bend, Toledo, Salt Lake City, Portland. Detroit's air in the meantime could be seen traveling off in a northeasterly direction, eventually curling back over, say, Cleveland, Pittsburgh, and New York. Of course, it would take a modern expert to tell you what this material is; we can only tell you what we see, and we see this envelope ranging from 2,000 to 30,000 feet deep, covering for the most part the entire United States. If for no other than esthetic reasons, it should be stopped and it's my belief that only the Federal Government can do it.

Millions of people have now flown who have never seen the earth as they ought to see it. In the 1930's it was of course a time of low industrial activity. Then our country was a joy to behold. Today, if you wish to see this earth as it truly is, you must be within 1 hour behind a wet cold front and at a comparatively low altitude. I asked Mr. MacKenzie 2 or 3 days ago if the information would be in the air pollution literature that on December 5, I believe, over the peninsula of Florida there existed what we might term an industrial garbage pit 6,000 feet deep. Visibility, instead of being 130 miles at 10,000 feet, was on the order of 12 miles. And if we were to ask a citizen there at that time if there was any smoke in the air near the ground, he could only say no. The weather reporting leaves something to be desired. We lost an airplane recently at Idlewild and it is my belief that smoke contributed as much to this accident as the fog.

J. O. Julson. I felt that Dr. McAfee's paper on "Industrial Statesmanship" presented guidelines for a sound, constructive, and basic approach to the solution of air pollution problems. My own company, the Weyerhaeuser Co., Pulp and Paperboard Division, would agree with the guidelines for action he presented. I recommend to this conference serious consideration of their adoption as statements of policy arising out of this conference.

McAfee. I want to thank the gentleman. Apparently the message got over to one man, at least. I hope there are others.

Fogarty. I think all the messages this afternoon got over. I think Dr. Commoner's on science was excellent. I think Dr. McAfee's, from industry's standpoint, was excellent. I think Senator Williams', from the political standpoint, was excellent.

Arthur A. Atkisson. Dr. McAfee, I must say that your speech and your proposals were interesting and, because of your background and your in-

tion problems if industry agrees that the phenomena under consideration are problems, if the control doesn't cost too much, and if government cooperates to the hilt in the process of control. I get the feeling that perhaps you were defining statesmanship more as the manipulation of pressures, particularly external pressures, on the managerial decision rather than as a kind of overpowering and overriding commitment to certain values and to a constant march toward the realization of those values. Hence my questions: When does a pollution phenomenon in fact become a problem, and what would you offer to your colleagues in industry as the proper definition of a pollution problem? When is a control measure a reasonable control measure and when is something economically feasible or unfeasible?

McAfee. I appreciate the compliment you imply by addressing that question to me, because obviously the answer is extremely complex. And there is no pat answer that can be given. As far as the guidelines I mentioned are concerned, I was talking to all of us—as private citizens, as members of government, as members of the industrial community, all of us. I also think they are sound principles that we can all be guided by. I certainly didn't mean to do any fingerpointing myself and, as I tried to point out in the beginning, I thoroughly subscribe to the point of view that air pollution abatement is a challenge and a problem that we all bear responsibility for. As to what constitutes the problem and when is it a problem and when is the solution reasonable, these things can only be resolved, it seems to me, by very close, honest, careful, day-to-day continual working together of industry and government at all levels, particularly at the local level, where the problem is perhaps best understood. And I submit that there isn't any real answer to your question except that which is arrived at by this process. When there is agreement among the local government people involved and the local industry people involved and the local public involved that there is a problem, and that something must be done about it, and that the cost must be borne somehow, then there's a real problem. item, then I'd say we had before us a technically feasible and economically sound means of controlling it and a reasonable solution. So it seems to me that these questions that you appropriately pose can only be resolved by very careful cooperation and continuing cooperation and working cooperation between government and industry in each local situation.

Commoner. I want simply to point out that Dr. McAfee's prescription will work if there is a solution to the problem. The difficulty that I'd like to remind you about is that, under the present circumstances, our technological power in physics and chemistry is sufficiently strong to produce problems for which there is no economically sound, feasible solution. We must learn how to avoid those problems. And here, it seems to me, there is no way of doing it short of asking every industry to undertake an examination of potential pollution of each new technological process at the same time it works out its cost figures and production schedules. This is going to be extremely difficult to do but, if we define a problem as one that has a solution, we're going to be faced with an awful lot of problems that will never get solved.

Harry C. Ballman. In addition to a question for Dr. Commoner, I have a comment to Captain Guthrie. I don't want to argue the matter of age, but I have been flying since trimotor planes were first made by Ford, Captain Guthrie. I think you've touched on a very good point. But I should also like to point out that you indicated that, if you fly low enough, you do not have much trouble with perception through the haze. Therefore, it seems to disappear. In the older days with the older planes, you had to fly at much lower levels. And I agree with you, it was a beautiful country to see. But certainly you wouldn't go to 20,000 or 30,000 feet in a trimotor Ford plane, and I think it's mostly this depth, like looking deeper into the ocean, that you're seeing. And many times, we come down out of 30,000 feet into this brown layer that you were talking about and, as you approach the ground—I'm particularly conscious of these things because I look at them quite often—it becomes better. I'm

talking about a clear day. So I would like to say just this one thing. Let's talk about the old plane of the 1,000-, 2,000-feet levels. Let's go back to the DC–3 which I'm unfortunately forced to travel on occasionally and see the beautiful ground and let's not compare this to the 30,000-foot depth. The same thing applies to the ocean.

Now to Dr. Commoner. I think your address on scientific statesmanship was an excellent job, well done. But I did notice the words "engineer" and "engineering" were more or less excluded from your talk and the emphasis was totally on the word scientist. I'm sure there are a number of engineers in the audience who would like their profession to be included in the scientific statesmanship of your paper.

Commoner. I should be happy to have engineers, as they should, consider themselves scientists. I think your point is well taken. As a matter of fact, I pointed out that chemical engineering is one of the important aspects of the problem that we're talking about. And that one of the characteristic things of modern science has been the very rapid way in which the gap between engineering and basic science has begun to disappear. The speed with which basic scientific advances, for example, solid state physics, are translated into engineering applications such as the transistor is now enormous. There has been a fantastic acceleration in the last 10 years in this speed. And this is, I think, one of the essential things we have to deal with. This means that the rate at which the engineers are able to make technological advances on technological problems is accelerating along with the size of the problem, and the size of the advances that they make. I certainly agree that the engineer has just as much basic responsibility here as the scientist and I hope that we shall see an increasingly strong alliance between them.

Eugene H. Clapp II. Senator Williams, numerous companies in this country are disturbed because of dumping of products from north of the border or from elsewhere abroad, and also because foreign countries with lower wage rates are introducing products into our markets today. I gathered from your remarks that, regardless of economics, your intent is to force control upon all industry. I wonder if you would clarify this point.

Williams. Are you suggesting that any controls imposed upon domestic industry should be extended beyond our borders to industries that are, as you say, dumping?

Clapp. I gathered from your remarks that the Federal Government should pass controls that might not be economic for industry in the United States. And the affected industry might not be able to afford to put in the suggested facilities—not just suggested but legislated by the Congress of the United States.

Williams. The bill that I subscribe to and endorse is one that makes available Federal grant money for control measures initiated by local governments. These governments are the originators of actual controls for air pollution. We haven't got any in this bill; it is not an enforcement bill. The Engle bill is not an enforcement bill. It does not call for Federal regulation, based on Federal law, of your private company. I don't believe that we're at a stage in the art of control where that's feasible. What we're trying to do is to undertake to get State and local governments doing what they can, first to find the way to control and then to put it into effect. I said later, however, that as we evolve in this field, the Neuberger idea of a national enforcement program—in theory, at least—might well be timely.

William A. Verrochi. In your speech, Senator Williams, you mentioned that research of course is one of the favorite tools in the practice of political gamesmanship. I assume that this is meant to be a disparaging remark against political gamesmanship and of course not against research. I wonder if you'd care to amplify. Do you feel that we haven't been following up as rapidly as research has shown us the way?

Williams. It seems to me that way. I had some things I was going to quote in which we are directed to study the effects of automobile exhaust and measure the degree of damage it causes. As a layman, I should think that we know there is a severe health problem arising out of the accumulation in the cities of fumes from automobile exhausts, and that we should not be measuring the effect, but working harder than we are at methods of controlling that exhaust. That's what I mean.

Raymond Smith. Dr. McAfee, your paper referred to a number of factors which I assume you feel industry itself is capable of weighing. If industry does weigh these factors independently, it should be equally capable of independently creating within individual plants or industrial groups a self-initiated control program aimed at limiting its own pollution—ideally, at least, on a voluntary basis—and without the influence of outside forces such as

Mr. Smith, is an ideal one that I'm sure we would all like to see attained. As a practical fact, I think it is simply recognizing facts and being realistic to say that very rarely can the degree of education and persuasion necessary to bring about completely satisfactory actions be achieved without some sort of organized approach to the problem on the part of the community. But this doesn't at all mean, in my judgment, that persuasion and education are not still important to those who are charged with the responsibility of air pollution abatement. I believe they should be utilized to the fullest possible extent.

Smith. You may have in part missed my point. I share with you the belief you expressed in your last statement that there is need for working together. There is certainly need for the first approach between government and industry to be on the basis of reconciliation and a common understanding of industry's problems. But sometimes this becomes a little wearisome. And the point I really hoped you would comment on was the question of the extent of industry's self-education within itself and of its carrying out of control programs within itself as a result of its own recognition of the problem within itself.

McAfee. Well, I think there are numerous examples of that, Mr. Smith, and without taking too long—and it would take too long to go into them fully—I shall mention one. If you will pardon reference to the industry that I happen to be most familiar with, the efforts of the petroleum industry contributed greatly to the overall understanding of what the real facts are about the photochemical type of smog that prevails in Los Angeles. This was a voluntary, unforced action which exemplifies the sort of thing I think you are driving at. The petroleum industry has put a lot of effort into this program, as you well know and as the people on the west coast know even better, and I'm proud to say it has had a small part in the much better understanding of what that problem really is that we have today compared with what we had back in the early 1950's, when we first addressed ourselves to it. At that time, all of us—and I'm not speaking of just industry or of just the petroleum industry but of everyone concerned—were pretty much flying blind, in that we had no real knowledge of the facts. I think it is certainly true that continued research, development, and improvement in control methods will lead eventually to the ultimate solution of the air pollution problems. But until we know what the problems really are, we are diluting and wasting our efforts and deluding ourselves, if we try to stab blindly with something that we might hope would be a solution when we don't really know what the problem is.

Robert L. Myers. Senator Williams, there have been repeated references and inferences that industry cannot afford to institute the control measures that are already available for the abatement of many air pollution nuisances. I wonder if there is any thinking in the Federal Government that, rather than spending money for grants to impose retaliatory legislation against industry, some attention might be given to helping industry finance what might be termed uneconomic control measures in the form of tax relief or some other type of financial assistance.

Williams. Let me say that I don't know of any legislation proposed or being worked on that is motivated by any spirit of retaliation. That is not the motivation at all. However, I think it is fair to say that there is at least the genesis of thought about ways of providing assistance of some kind in the economic sense to help industry conform to the measure of control which the scientists and the engineers find feasible in terms of dealing with pollution but which might be uneconomic in terms of Dr. McAfee's position. In this tax-cut year, I don't think chances are good for this new kind of grant or loan or whatever it would be, but it is being thought about as a possibility for the future.

Edward J. Pugh. I agree with the airline pilot about haze. There's an almost constant haze over the rural mountain areas in northeastern Pennsylvania.

Arthur J. Benline. Apropos of Captain Guthrie's comment, I have seen considerable smoke and smelled the very heavy oil concentrations at many airports, especially Idlewild, when a large number of jets are taking off in a short period. What about the Federal Aviation Agency and the airlines policing this aspect?

Fogarty. I suggest you write them a note. I don't know what, if anything, they're doing about it.

Worden Burke. Are neighboring countries such as Canada aware of the air pollution problem and are they attempting to solve this problem also?

Fogarty. The answer, as far as I know, is yes, because we have several representatives from Canada who are attending this conference. I think the invitation extended by Mr. Huntzbuchler about the coming conference in Europe is also a good indication of interest on the part of people in other countries. They are concerned about it and they are trying to do something about it.

James L. Dallas. I have been employed by a Massachusetts regulatory agency for some time. As I've listened here this afternoon, it has seemed to me that many people feel that the air pollution control cloth has been cut up and that there's a sleeve missing; I do not think this is so. I feel that we have adequate constitutional setups, both at the Federal level and at most State levels. Upon examining the constitution, as we have had to back at my State level, it has seemed to us that it adequately provides the basis for governmental air pollution control programs. It is our job as a regulatory agency to adopt regulations as required by the legislature. Legislators, in turn, as politicians and statesmen sense the feelings of, and act in the best interest of, industry as well as the citizenry as a whole. In doing so, they are supposed to also become knowledgeable as to the opinion of the experts and specialists in the problems at hand. It has seemed to me that this democratic system works fine. Again I say, the legislators must feel the pulse of the people, evaluate the problem, and act in the best interest of all.

There is one thing that *has* been missing from all of today's discussions, and that is mention of the courts. I have felt that if we have ever been too extreme in our regulations, when drafted as directed by the legislature, then individuals have resort to the courts, which then make the judgment for the people as to whether our actions are reasonable or not.

Another check and balance available to the citizenry or vested interests is through lobbying and pressure upon their elected officials to amend or rescind enabling legislation to clip our wings if necessary. In the democratic system they must act in conformance with their conscience and the wishes of the people to be reelected. The democratic processes function as a whole.

In regard to the statements by Dr. Commoner this morning, I suggest that the courts are one place to resolve the problem as to how to balance the hazards and costs of pollution against the benefits and costs of its control.

I also feel that we all have responsibilities in air pollution control and that most regulatory agencies try to use persuasion first in effecting control; we have found this policy to be effective in Massachusetts.

Sam Della Maggiore. First, I want to give the engineers here some reassurance about their position in this field. As Dr. Lee Dubridge put it at Cal Tech recently, "When a rocket works, it's a scientific achievement; when it doesn't, it's an engineering failure." In air pollution, too, you engineers have a big responsibility.

I represent the Bay Area Pollution Control District, which comprises the six counties around San Francisco Bay. We have a good representation at this conference, including five directors, three advisory council members, and one staff member. The Surgeon General this morning mentioned the fact that California has taken the lead in dealing with many air pollution problems and, as most of you know, California is now the No. 1 State in population, so it's up to us to keep on providing this leadership. The recommendations we are presenting are backed 100 percent by the California League of Municipalities, the State of California, the State Supervisors Association, and the Los Angeles Air Pollution Control District, as well as by our Bay Area Control District. Maybe some of our recommendations can be dealt with by administrative action here in Washington, and for others we may have to depend on new legislation, introduced perhaps by legislators who are here today, Congressman Fogarty or Senator Williams. Whichever the case may be, we hope that they will be put into effect.

[*Editor's Note:* The Bay Area recommendations are reported under the Panel Sessions to which their subject matter applies, Panels A through G.]

James R. Jones. Dr. McAfee emphasizes strongly the practical aspect of air pollution elimination, and this is the aspect with which I am principally concerned. I am an engineer dealing with fuel-burning equipment. In order to eliminate these problems, someone has to work with the industrial plant and with the local air pollution people, and it's from this angle that I'm speaking. I should

where. Each community must arrive at its own economic solution. Rules and regulations that drive an industrial plant out of a community are not a solution in any practical sense. That kind of solution loses jobs for the community. It takes money away from it. It causes distressed conditions. The practical aspect must be considered, and air pollution elimination can come only as technological progress permits. We can't just push a button and have all air pollution stopped. There must be an economic balance between investors' capital, employment, community relations, and local support.

Francis Silver. Captain Guthrie has given me a suggestion that seems to me one of the most intriguing that I've run into. He suggested that they charge sort of a tax on dumping into the air, perhaps $25 a ton for dust or sulfur dioxide. That would put this whole business of air pollution on a sound financial basis. We would have money to pay for the cost of air pollution control and research; also, it would pay the man who is polluting the air to correct that kind of thing.

Fogarty. Before I call on Mr. MacKenzie to read two communications from the two Senators from California, I shall ask the two remaining panelists to sum up in 2 or 3 minutes what they think of this session, and also, of course, to say whatever they want to. Dr. McAfee, let's start with you.

McAfee. As to what I think of this session, I think it has been a very interesting and fruitful and constructive discussion. And I hope that we have all profited from it. I'm sure that I have. I want to make two other comments.

First, to elaborate a little on my earlier response to the question by Mr. Smith of Philadelphia, I shouldn't want anybody to go away with the impression that, having cited an example out of the petroleum industry, I am neglecting, or want you to be unaware of, tremendous similar efforts which have been made by other industries all across the Nation in this important field of air pollution control, which—as we have said several times—is one which is receiving continuing and accelerating recognition on the part of industry as well as by voluntary efforts, which have resulted from excellent cooperative efforts at a local level. We have numerous examples, outstanding examples, where this approach has paid off. It seems to me that this is a good place to clear the air on this particular point. Let's disabuse ourselves of the concept which seems to exist in some people's minds that industry is responsive only to coercion. Industry is responsive to coercion, but it's also responsive to other forces and other pressures and other incentives and motivations, which in the long run are much more effective in getting done the job that's before us. If Mr. Smith were to follow up his question by asking me if I think that voluntary efforts alone will solve the problem in all cases—of course, the millennium has not yet come, and I think there will be a decided place for the control official and for the control organization in crystallizing the standards which must be met and the goals which must be set.

My second point is this. It seems to me that a lot of the apparent differences of opinion which have cropped up now and again about local control or local regulation or local enforcement, on the one hand, as against control or regulation or enforcement at a higher level, would perhaps be clarified, at least to some extent, if we would inquire whether or not we are all saying the same thing when we use the word "local." It's not necessarily a small or an arbitrary governmental limit, but rather, that area, large or small, which is affected by a common source or a common group of sources of potential pollutants. When we recognize that, we embrace the concept which was eloquently expressed in the statement from the San Francisco Bay Area Air Pollution Control District. What we are really talking about may be in some cases a given town or city or county, but in other cases we may have to go across city or county or even State, and occasionally, even international boundary lines. I believe that this "local community" can be synthesized, if you will, by existing governmental procedures and legal approaches without resorting to Federal regulations which will perhaps get the job done in some cases, but which will either overdo or underdo the job elsewhere.

I want to express to everyone here my personal appreciation—and also that of industry in general, I feel sure—for the opportunity which has been afforded at this particular session of this important conference to present what I sincerely believe to be a sound viewpoint and one which I believe with equal sincerity to be generally shared by the industrial community.

Commoner. The main thing I'd like to say is that I've been sitting up here getting thoroughly educated in certain important aspects of this problem that I hadn't been aware of, or at least not as fully as I should be. It seems to me that the people who are working in plants, in industries, and in control organizations are up against very hard economic facts and, as I see it, most of you who have been listening to some of the brilliant ideas that have been put forward up here have been worrying about how you are going to act on them without offending the stockholders, without going broke, and without losing your competitive position to industries abroad. And I respect that position. I'd like to tell you what I've learned. It seems to me that the economic difficulties that industry will face are going to mount up if something isn't done about air pollution soon.

As I see it, there are several prices that industry and technology generally are going to have to pay if we don't do something about this very difficult and expensive thing. In the first place, I think the suggestion that was made about paying for the air is a good one, your use of the air, that is. It seems to me that when you put pollutants into a stack, you are using the air in order to carry out an economically useful process. You don't expect to get your water for nothing and I think that the air is being used in the same economic way and should be paid for. The reason why I suggest this is that it will make clear what the cost of using the air really is. One of those costs arises because the air is changing in such a way as to make it less useful to industry. For example, I'm told that a chemical laboratory in Los Angeles that wants to carry out certain tests on amino acids now finds that one of these can't be carried out because the air oxidizes the amino acid. I can readily see certain industrial processes that will be made very much more expensive because the whole laboratory will have to be surrounded by a filtered environment. What I am driving at is that if the air is a limited resource, the closer we come to using it up, the more expensive it is going to be to continue to use the air. And it seems to me that the old idea of spending a little now in order to save a lot later applies perfectly here.

The second asset that's going to be used up if we don't do something about the air now is public confidence in the way we use our resources. No one can dodge the fact that the public is becoming increasingly aware of the difficulties and hazards that are involved in unlimited expansion of the dissemination of chemicals. I don't think that you can laugh off the kind of thing that's been happening in connection with thalidomide or Rachel Carson's book about pesticides. You may say that this is just talk. The important thing to remember about the people who are the public is that they're customers. I think they want to feel that the producers have in mind the welfare of the community as a whole and it seems to me that it's economically sound from the very beginning for industry to say: "Let's not have a flap like this about air pollution 10 years from now; let's start now to do the right thing so that there won't be trouble."

And the third thing that's going to be used up if you don't do something about air pollution is probably more serious than anything else. All of the strength of modern industry comes from science and engineering. Now science and engineering are not immutable tools. They are instruments that will change with the way in which they are used. I hesitate to think of the kind of scientists that we're going to have in the future if we don't straighten out and deal with our problems in a scientific way. I find it's very difficult to explain to a student that, when we embark on new technological developments and disseminate new chemicals very widely, for example, it's not scientifically sound. Then I have to sort of shrug my shoulders over the fact that we continue to do it. Students are going either to come to the conclusion that I'm wrong about the principles of science or else they're going to start bucking the kind of thing that's happening. In either case there's going to be difficulty. There's going to be difficulty because you will find that the integrity of science, its ability to get at the truth, its ability to produce new power for industrial use—I mean scientific knowledge for industrial use—are all going to become weakened.

For these three reasons, I suggest that it is economically foolish to avoid the issue of preventing air pollution, however expensive it may seem to be today. And if the job is difficult, then I say we have to recognize it and find very powerful ways to

who have no direct interest in air pollution, will rally behind you and try to help. I think that this meeting, if it helps to bring this difficult problem before the scientific community, will also help a great deal in finding new ways to solve it. I have enjoyed this discussion very much because I have been enlightened by it.

Fogarty. Thank you, Dr. Commoner. I think it's well for each of us in an elective office to hear all sides of a story like this, and I have learned a great deal today. I now thank you for listening, and turn the meeting back to Mr. MacKenzie.

Vernon G. MacKenzie. Thank you, Congressman Fogarty. I have two statements to read. The first is by U.S. Senator Clair Engle, of California, who expresses to all of you his regret at being unable to be here.

Clair Engle.[1] Air pollution is no longer just another "problem." It is becoming a scourge.

I will not attempt in this brief message to spell out my views on the whys and wherefores of the subject.

I will state just this: We don't yet have the answers; therefore, intensified basic research is a prime necessity. I think the sponsors of the National Conference on Air Pollution are on the right track in emphasizing this approach at this meeting.

Many of you are aware that I introduced legislation toward this end near the close of the 87th Congress. The bill is S. 3784. I introduced it in October 1962 in order to permit you people and other experts to look it over and evaluate it in advance of the 88th Congress. I intend to reintroduce this bill with such modifications as may be appropriate in January 1963.

Accordingly, I ask that you who are interested in Federal help look up S. 3784. New legislation of this nature is needed, because the Air Pollution Control Act of 1955, although amended last year, expires in 1964.

My purpose in proposing S. 3784 is to speed up and to expand Federal assistance to State and local agencies engaged in this important work. The bill calls for a concentrated 10-year national program of research and development in an effort to find a solution to the problems of automotive, industrial, Conference to bring the legislation—S. 3784—to your attention. Once more I say I am sorry I could not attend. I thank you for the privilege of submitting this statement on the legislative aspect of the subject.

MacKenzie. The second statement is from U.S. Senator Thomas H. Kuchel, also of California, in the form of a letter to the Surgeon General, Dr. Luther L. Terry.

Thomas H. Kuchel.[2] The second National Conference on Air Pollution recognizes the lamentable fact that contamination of America's atmosphere is no peculiar phenomenon occurring only infrequently in time or confined to some particular community or region.

I regret my inability to attend these sessions, which I know will be both informative and challenging. As author of Public Law 159, which first put our Federal Government actively in the fight, I would have liked to express my thoughts in person and also to have obtained firsthand the views and comments of those who have been in the forefront of the effort to stamp out the curse of polluted air.

You indicated to me your program contemplated discussion of the desirability of "statesmanship" in this important effort. May I take this opportunity to convey some thoughts I have on this aspect of the matter?

There is no question in my mind that at all levels—technical, legislative, educational, and otherwise—all of the arts and resources of what that term connotes must be employed if we are to achieve our goal—clean, pure air for our citizens.

There is an undeniable need for persistence, imagination, cooperation, leadership, understanding, diplomacy, and resourcefulness, all of which are characteristics attributed to statesmen.

It accomplishes little, for instance, to acquire scientific knowledge which cannot be put to practical use; there is scant progress in adopting regulations or devising remedial programs if the necessity for or desirability of such measures is not understood by the public; enforcement procedures will be ineffective unless carried on with equity and tact.

The pernicious and obnoxious effects of what we in Los Angeles have known and suffered as "smog"

[1] Read by V. G. MacKenzie.

[2] Read by V. G. MacKenzie.

for two decades demonstrably are more common than originally believed. Experience, unfortunately, has proved that even our National Capital is not immune, even though it has little heavy industry. Likewise, communities situated in sections commonly regarded as wide-open space, because of the vagaries of wind and weather, combined with traffic volume, residential development, and other aspects of modern civilization, have suffered affliction.

All of these circumstances lend emphasis to the urgency of more determined and intensive efforts, in various fields and different directions, to identify, isolate, and eliminate or control the source of contaminants. To achieve success, a high degree of statesmanship is a basic requirement.

As you well know, I long have felt that additional legislation by Congress is justified and desirable. I also believe that our States, counties, and cities must recognize a greater obligation and, wherever indicated, adopt laws, ordinances, and regulations. To date, I have not been convinced that Federal authority should be exercised in police fashion, but I do fear that unless statesmanship is shown at non-Federal levels there may be no alternative if we are to safeguard the public health, let alone protect property and animal and plant life, and keep physical discomfort to a tolerable minimum.

To my regret, it was impracticable during the 87th Congress to obtain approval for the bill I introduced which would have given the U.S. Department of Health, Education, and Welfare and the Public Health Service additional authority and responsibilities I feel are essential to maximum progress in this field.

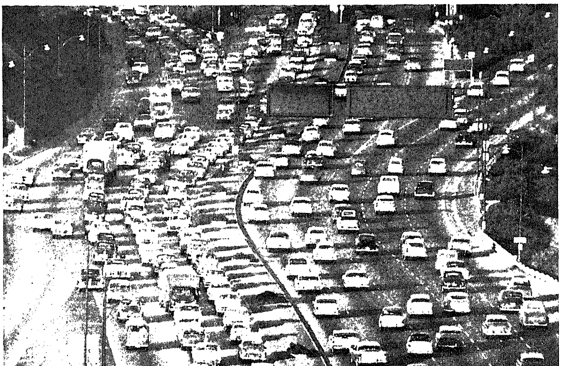
I earnestly hope that during the proceedings of the forthcoming national conference, serious attention will be paid to the desirability of meaningful new legislation on the subject of air pollution. I trust that those participating in these discussions will help provide the degree of statesmanship imperative to drafting and enacting additional measures which will give further impetus to activities already going on and bring into proper focus aspects of the problem to which insufficient attention has been given.

I look forward to reviewing the record of the meetings with real eagerness and with confidence that constructive ideas will be advanced.

With best wishes and warm regards.

Panel A

THE AUTOMOBILE, THE TRUCK, AND THE BUS



Public Asks About

Chairman: WOLFGANG E. MEYER
Co-Chairman: JOHN D. CAPLAN
Reporter: JOHN A. MAGA

Participants

WOLFGANG E. MEYER, Professor of Mechanical Engineering, Pennsylvania State University, University Park, Pa.

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NORTON NELSON, Director, Institute of Industrial Medicine, New York University Medical Center, New York, N.Y.

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JOHN A. MAGA, Chief, Bureau of Air Sanitation, California State Department of Public Health, Berkeley, Calif.

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AIR POLLUTANTS FROM MOTOR VEHICLES

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Various aspects of the complex problem of air pollution by motor vehicles will be discussed by the panel members. In order to provide a frame of reference for the experts' discussion of specific aspects of the overall problem we ought to look first at what air pollutants motor vehicles emit.

It is often thought that passenger cars, buses, and trucks produce different types of exhaust emissions. This is only partially true. The real difference lies in the types of engines used; buses and trucks may have either gasoline or diesel engines while passenger cars usually are powered by gasoline engines. We should, therefore, think more in terms of engines than of vehicles when we talk about exhaust emissions. The type of vehicle in which an engine is used does have, however, an influence on the quantity and, to some degree, on the character of the emissions. Engines in passenger cars operate at much lighter load than those in trucks and buses and emissions change with load, speed, temperature, etc.

Both gasoline and diesel engines operate on hydrocarbon fuels that are obtained from petroleum by various refining methods. These fuels are burned within the cylinders of both engine types to convert chemical into mechanical energy. To burn the fuel, air is needed as a source of the oxygen that must be available to combine with the hydrogen and carbon of the fuel. This combination process produces heat and, in the confined space of the engine cylinders, pressure. It is this pressure that propels the pistons and thereby turns the crankshaft and ultimately propels the vehicle.

When the hydrogen and carbon that are the elements that make up petroleum fuels combine with oxygen, water vapor and carbon dioxide are formed. Both of these products of the ideal, complete combustion are invisible, cannot be smelled, and are harmless. We see the water on occasion, namely, when the engine and the air are cold. We certainly know it must have been there when we pay good money to replace a rusted-out exhaust system.

Unfortunately, however, combustion in an engine never conforms completely to the ideal and idealized model of the process. The products of imperfect combustion are the prime cause of the motor vehicle air pollution problem. One of these products is the carbon monoxide that gasoline engines emit. Almost everybody knows this and is aware of how dangerous carbon monoxide is. Numerous other substances are produced, but usually in much smaller quantities. Motor fuels also contain certain additives that are necessary to give the performance and life that we have come t expect from engines. These additives underg chemical changes during combustion before bein emitted into the atmosphere. Also a certai amount of lubricating oil burns or partially burn in the cylinders. If an engine is so badly wor that a large amount of oil is pumped by the pisto into the combustion chambers, the vehicle will tr a plume of blue smoke that consists of partia burned or completely unburnt lubricating oil.

It is not only the engine exhaust system, h ever, that discharges all manner of substances i the atmosphere. Another important emission p is through the engine crankcase. Despite great vances in the technique of sealing pistons, a s amount of the gases in the combustion cha escapes past the pistons into the crankcase. In past, this "blowby" was permitted to pass int atmosphere, but now devices are being used to vent its discharge.

It is the concentration of a great number of vehicles in any one area, particularly in cities, that creates the problem. The estimate that by 1970 there will be three automobiles for every two in use today is what creates concern regarding motor vehicle emissions, even in metropolitan areas in which currently air pollution is not serious.

A gasoline engine compresses a premixed charge of air and fuel vapor prepared by the carburetor. This charge is ignited by an electric spark, causing the fuel to burn. Combustion is most efficient when there is slightly less fuel than could be burned completely with the available air. Under these conditions, the emission of pollutants is at a minimum. Carburetors are designed to deliver such lean mixtures when the engine operates at steady state and part load.

Maximum power is obtained with a mixture that is slightly richer than ideal, that is, when there is more fuel than can burn with the available air. It is then that the emission of pollutants is significant. Actually, full power is used in city traffic only rarely and for short periods, even by trucks and buses. Therefore this condition is still not one that is cause for serious concern, even though emission of pollutants is high. Unfortunately, however, it is also necessary to operate with rich mixtures at idle and, during acceleration, if the engine is to perform smoothly and respond to the throttle as readily as we have come to expect it to do. Emissions also reach serious proportions during deceleration, when the throttle is closed. Little air reaches the cylinders at that time, but fuel flow remains high, at least during the early part of the deceleration process, and combustion is poor. Not much can be done about the high emission levels during these operating conditions unless we are willing to accept either less than perfect engine behavior or the cost increase that radically different fuel systems or corrective devices would demand.

Superimposed on this is the fact that engines are frequently in a less-than-perfect state of repair and adjustment, particularly as certain components deteriorate with time. Scrupulous maintenance and careful attention to ignition timing and other monoxide will be present in the exhaust. There also will be unburnt fuel and the large variety of products of incomplete combustion such as peroxides, aldehydes, ketones, esters, ethers, alcohols, etc. The actual composition of the exhaust gases varies from engine to engine, changes with the operating mode, and is influenced to some extent by fuel composition (all fuels being mixtures of a great number and variety of hydrocarbons).

There also will be some particulate matter in the form of carbon and tar that may contain polynuclear aromatic and long-chain aliphatic hydrocarbons, some of which are suspected of being carcinogenic. Lead and iron compounds (from antiknock additives and from abrasion of engine parts) and sulfur dioxide may be emitted as well as small quantities of other materials that originate from fuels and lubricants, and their additives and impurities.

In addition to all these substances the engine emits oxides of nitrogen. These are produced by combination of the oxygen and nitrogen of the combustion air in the presence of high temperatures. Their concentration in the exhaust depends not only on the temperatures prevailing in the engine combustion chamber, but also on the competition for the oxygen by the fuel that is present. Nitrogen oxides produce toxic effects, but they are also suspected of playing a vital part in the photochemical reaction that leads to smog formation.

Evaporated fuel that enters the atmosphere without passing through the engine will consist mainly of volatile hydrocarbons. Blowby gases contain the same constituents as the exhaust gases, but have a much higher content of unburnt hydrocarbons because they consist largely of fuel-air mixture that escapes from the combustion chamber before ignition takes place.

The diesel engine differs from the gasoline engine in that it uses heavier, that is, less volatile fuels, that it compresses air only instead of a fuel-air mixture, that fuel is injected into the cylinders at about the same moment at which the electric spark occurs in the gasoline engine, and that the injected fuel autoignites by contact with the air that has been heated by compression. The important difference

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is that combustion does not take place in a homogeneous mixture as it does in the gasoline engine, but around and within the fuel spray as it is injected. Therefore mixing of fuel and air is apt to be incomplete. Some of the fuel burns therefore under conditions in which insufficient oxygen is available at the time it is needed. To prevent this from happening, various combustion chamber designs are in use that promote mixing, and less fuel is injected than could be burned theoretically in the available air.

When combustion is starved of oxygen, carbon is formed and this carbon is visible as the familiar black diesel exhaust smoke. Since smoke is an indicator of incomplete combustion and hence of a waste of fuel, manufacturers go to great pains to insure as complete combustion as possible and to limit the amount of fuel that can be injected into the cylinders. When you see a smoking diesel you may be sure that it is either poorly maintained or that someone, in order to obtain a little extra horsepower, has adjusted the engine to receive more fuel than the manufacturer intended it to receive. Lack of maintenance may involve no greater problem than a clogged air filter which lets the engine receive less air than it needs. Or one or more spray nozzles may not atomize and distribute the fuel properly.

At part load, a diesel rarely smokes because, to reduce its output, only the fuel flow is reduced, so that the proportion of air in the combustion chamber increases. (In the gasoline engine both air and fuel are throttled proportionally so as to maintain a constant air-fuel ratio.)

As we all know, diesels smell. The odor is often attributed to the emission of aldehydes, but its actual cause has not yet been defined. The odor-producing substances are emitted in greater quantities by diesels than by gasoline engines and as somewhat different species. Before, however, putting the entire blame for exhaust odors on the diesel engine, it is well to remember that poorly tuned gasoline engines also can generate a great deal of odor. Many times people exposed to the exhaust of a city bus believe they smell a diesel engine when the bus actually has a gasoline engine.

As far as the emission of other air pollutants is concerned, the diesel is definitely less of a problem, if only because its carbon monoxide production is practically zero, at least as long as there is no smoke. As soon as smoke appears carbon monoxide appears and both increase together. Other exhaust constituents are not vastly different from those of gasoline engines. Oxides of nitrogen are produced in somewhat greater quantities, while unburnt hydrocarbons are nearly absent. The absence of the latter is an important factor as far as the control of Los Angeles-type smog is concerned because its formation depends on the presence of hydrocarbons.

Diesel blowby gases contain only small quantities of pollutants because the diesel compresses air only. And since the diesel uses less volatile fuels, the evaporation loss from the fuel tank is negligible. Diesel fuel systems are closed, so there is no escape path for fuel vapors there.

Because the number of diesel-powered vehicles is relatively small and because they contribute even less to city mileages, being numerically mostly heavy trucks, not very much research has been done on diesel emissions. Actually, we still don't know everything there is to know about the emissions of gasoline engines. It is only since the midfifties that a broader awareness of the contribution of motor vehicle emissions to air pollution has developed. Early attempts to understand the character and the role of exhaust emissions were hampered by lack of instruments capable of detecting and measuring the various constituents. Most of these occur in such low concentrations that they must be measured in parts per million.

It is really a tribute to the researchers in this field that we know as much as we do about exhaust emissions, their effect and their control. With this thought I commend to your attention and appreciation what our speakers have to tell you about the complex problem of air pollution by motor vehicles. These men are among the best experts in the field. I am sure they will not be offended if I say that their reports here today reflect not only their own work and achievements, but also those of many other researchers equally capable and dedicated.

POLLUTANTS FROM OTHER SOURCES

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Since the planners of this symposium have provided no clues to the concepts from which my assigned subject was generated, the inherent ambiguity of the words leaves much latitude of choice from among several possible interpretations. For example, it is possible to affirm categorically that pollutants from sources other than vehicular are additive, the sum of the muck from the two types of origins being the so-called "total pollution load." But this would tend to perpetuate the fallacy that "total pollution load" has predictive or other useful values for understanding, or for action on, the air pollution problem. We have progressed at least far enough to know that a ton of sand demands less attention than a ton of nitrogen dioxide.

Another interpretation might involve consideration of what, with some violence to the niceties of semantics, is often referred to as "synergism" in the effects of the several emitted chemical and physical species on their human or other receptors. This is a matter which has been talked about and written about often and at length, but is still almost wholly speculative, probably because experimental analyses of synergisms involving only two species of gases or particles have proved difficult, and no known techniques can deal with a dozen or a hundred species simultaneously involved in a dynamic atmospheric situation. Automobile exhaust released into sunlighted air is such a system; even though it has been subjected to intensive study for several years, we have only limited knowledge of the manner in which variation of any one of its constituents alters the pollutional characteristics of the others. A few studies have recorded variations in end products or intermediate products resulting from the introduction of larger quantities of constituents already present in the engine exhausts. Sulfur dioxide and oxides of nitrogen have thus been shown to affect the directions and rates of reaction chains in the radiated mixture. In a study reported recently, iodine vapor introduced into the unstable complex has been shown to have the effect of suppressing ozone, one of the intermediate products. This observation demonstrates clearly that the properties of the irradiated exhaust system *are* affected by the introduction of relatively small amounts of a pollutant from another source. In this case, the "foreigner" apparently accelerates the chain of photochemical events which includes a by-product formation of ozone. Since the additive seems also to speed up other oxidation events, the total study suggests that at least one type of nonautomotive pollutant could seriously aggravate an already serious situation. In these experiments, as in the exhaust-laden city atmosphere, ozone seems to be an easily measured indicator of events and intermediates much more closely associated with tissue irritation and aerosol formation than is ozone itself. Where the parent processes are accelerated, the eye smarting may be made more severe with or without accumulation of ozone.

No doubt there are other reported studies which could be cited to sustain the thesis that additions to the vehicular exhaust system affect its pollutional potential. Certainly the numerous excellent theoretical and laboratory studies of processes involved in the photochemical reactions of hydrocarbons and oxides of nitrogen lead to the conclusion that almost any substance not totally inert must become involved in the reaction in some

degree. Free radicals have a voracious affinity for anything not otherwise occupied at the instant of contact. But discussion of the magnitude, quality, or properties of resultant products beyond this point within the framework of existing evidence would be a presently profitless subvention of the laboratory scientist's domain. We need more information; he needs more and more support to meet the increasingly exacting demands of his research in this extraordinarily complex and potentially fruitful area of ignorance.

Now, having come deviously through the appeal for research support that must always be sneaked into discussions of scientific and technical aspects of practical problems, and having foreclosed another possible approach to my subject for lack of information, we may look about for still another interpretation of the topic.

Let us consider the case of a community in which some political, economic, or engineering miracle has succeeded in complete elimination of engine exhausts, crankcase gases, and evaporated gasoline. It has frequently been suggested by office seekers and other attention seekers that such a sublime state could be reached overnight in Los Angeles if the county's scientists and other officeholders were not afraid it would terminate their employment. Nevertheless, the condition appears to me to be wholly hypothetical, even after having left the county payroll myself; its postulation will serve, only for the moment, to facilitate the examination of a comparative relationship vis-a-vis vehicular pollutants and those from other sources. One other condition is assumed, namely, that pollution from the other sources is not controlled.

It may occur to you that the system we have created imaginatively has had its real model in an earlier day when there were no automobiles, but further reflection must bring the realization that transportation is only one of many aspects of metropolitan activity that have changed. Even in those cities still reliant on coal as the prime energy source, combustion processes have been modified to such a point that domestic and industrial stack effluents have little resemblance to the thick black stuff which was the symbol of prosperity in the heyday of the horse.

From the air of our pipedream city, certain things would be missing; certain qualities would differ from those which prevail in reality. Notable among the absent would be the unsaturated hydrocarbons, which are attributable almost exclusively to gasoline and its use in driving internal combustion engines.

Certain other things would be present in higher proportion relative to the total. Among these would be nitrogen oxides, saturated hydrocarbons, sulfur oxides, and the gamut of types of particulate materials, since these would be only fractionally reduced in output. They arise from many sources other than the automobile.

Considering only these alterations, what could be expected to result on a hot summer day under strong inversion conditions without much wind? A most obvious conclusion would be that the rate of photochemical formation of smog products and irritating intermediates would be reduced, since the unsaturated hydrocarbons have been shown to be substantially more reactive than their saturated relatives. On the other hand, the increase in relative amount of nitrogen dioxide would very probably offset some of the gain, since the products of its photochemical dissociation would no longer be selectively scavenged by olefins, and since the rate of photochemical reaction with saturated hydrocarbons is increased by increase in the ratio of NO_x to HC. The net effect would be a reduced rate of smog formation: very probably a reduction in maximal levels of ozone, polyacetyl nitrates (PAN), and other intermediate compounds. Whether the accumulations of smog would reach troublesome levels or not would depend on the amounts of nonvehicular emissions in the air as well as on their relative proportions. Obviously the absolute quantities emitted will be related to the human activity density in the locality.

Similarly, the lack of vehicular pollutants must have an effect on levels of sulfur dioxide and trioxide in the air of our immobile city. The amount of SO_2 thrown into the atmosphere will be fractionally lowered; on the other hand, its participation in the photochemical transformations resulting in aerosol formation will be affected to a degree related to the rate changes imposed more basically by the elimination of the highly reactive olefins. Laboratory and field studies have clearly established that some of the SO_2 in the air is scavenged rapidly by incorporation into the reacting system. Sulfur-containing intermediates and end products result in course, but the effect is to minimize accumulation of SO_2 per se. In the absence of vehicular pollutants, it is reasonable to anticipate a rise in measured maxima of sulfur dioxide, simply because the mechanisms for its removal have been

more tolerable than the organic sulfur compounds which are its normal replacement is a matter of conjecture. In general, we know of incorporation of sulfur into the particles of light-scattering smog, and of the formation of what Johnston has referred to as "sulfur-containing organic acids." But the specific identities of these interesting deviatives and their toxic or irritative properties are essentially unexplored. It may well be that their avoidance at the expense of a bit higher exposure to sulfur dioxide would be a net gain.

The cold fact seems to be that, while more has been written on sulfur dioxide and its rates and routes of degradation through acid to neutral salt than on any other aspect of air pollution, we still have no real working knowledge of the sulfur-containing atmospheric system. By working knowledge, I mean information on pathways and rates of interactions involving sulfur, which can be used in predicting the effects of engineering controls on the net noxious product of SO_2 introduced into a polluted air supply, with or without the presence of automobile exhaust. It is obviously insufficient, even meaningless, to regulate SO_2 emissions in relation to the amount of residual SO_2 found in the atmosphere, unless it can be shown that its reaction products are qualitatively of no consequence. Likewise, it is often misleading, and always a questionable procedure, to measure SO_2 in an atmosphere, without some more comprehensive indication of the total sulfur content of the complex, and of the identities of other associated sulfur compounds.

In our hypothetical exhaust-free city, the toxicity of SO_2 itself might be of greater concern than in a real city, but there would be no less need for interest in its derivatives, since the catalytic and photochemical processes influencing their formation would still be operative even though altered in detail.

But enough of this metropolitan air supply that can never be; it is clear that the relative impact of primary and derived pollutants would be altered, in some cases favorably and in others unfavorably. It is equally evident that their qualities would have significance to the health and welfare of resident populations in some relationship to the absolute amounts of pollutants introduced into each unit of air. Since, for our larger cities at least, these quantities are roughly proportional to the numbers of pollutants other than vehicular must, by themselves, pose a challenge to responsible community leadership.

Please draw no inference from the foregoing that the net smog formation would not be substantially reduced by elimination of vehicular air pollutants in the special case of the Los Angeles basin. In that area, the quantities of all major contributions to the atmosphere are known in detail, and emissions from most major sources other than vehicular have been reduced to a degree not yet attained elsewhere. Under these circumstances, it can be asserted with assurance that the magic formula for complete cessation of pollution from gasoline usage would curtail serious smog episodes during some years.

But the circumstances which prevail in Los Angeles are not duplicated elsewhere. In most metropolitan areas, pollution from vehicular sources comprises a much less important factor in the airborne mixtures; its removal, without concurrent reduction in pollutants from other sources, would have a less pronounced effect. All this is probably a very wordy way of saying that it is insufficient to eliminate any single source of pollution; all of them contribute to the objectionable qualities of a polluted atmosphere.

As another, and final, approach to the assigned subject of this paper, we may turn from the hypothetical (and impossible) case to the more realistic probabilities inherent in the present effort to minimize automobile exhausts. Frequent reference will be made during this Conference to the Air Quality Standards adopted in California. In spite of the current—and justifiable—concentration on abatement of vehicular pollutants, it is obvious that some of the kinds of pollution already recognized as objectionable or hazardous in the governing code have little or no relationship to the automobile, while some others are only partially traceable to vehicular sources.

With accomplished control of exhaust and crankcase emissions, these types of hazard will continue to concern us in proportion to the increase in nonvehicular sources. SO_2, NO_2, and particulate matter arise from other combustion processes. Not only will they continue to be produced, but also their potential for accumulation to dangerous concentrations may actually be increased, because the

rapid photochemical conversion made possible by the presence of exhaust hydrocarbons will be retarded in some inverse relationship to our success in eliminating vehicular pollutants.

The California Air Quality Standards, insofar as they relate to engine exhausts at all, are based on an assumption that the objectionable properties of Los Angeles smog would be effectively eliminated by keeping the levels of exhaust emission at about 30 percent of the 1960 values. In order to achieve this 1940 state of relative freedom, rules were adopted requiring afterburners to perform in such a manner as to destroy 80 percent of the hydrocarbons, and 60 percent of the carbon monoxide contained in an average exhaust. Unfortunately, it is now quite certain that the "average exhaust" on which the absolute emission standard of 275 parts per million HC was based, is not at all representative of the output performance of numerous fleets of cars tested more recently. It seems reasonably certain that the present goal of 275 parts per million of hydrocarbon per vehicle would represent a reduction of only 50 to 60 percent of the actual emission.

Even this degree of abatement would, if realized immediately, have a marked minimizing effect on formation of photochemical smog. However, we are dealing with a real situation in which perfection in application of the rule appears to me to be unattainable for many years. First there are the technical facts of life. All of the proposed devices with which I am familiar require a "warmup" period before becoming functional at all. Since this time is normally several minutes, it follows that for a substantial fraction of the average triptime the control device will be inoperative. Thus the overall effect of installation on all vehicles would be curtailed to something like 40 percent reduction of current output.

But the current level is not the level of output with which we have to be concerned. Nothing appears likely to change the rate of increase in number of operating automobiles during the next decade. Nor is economic or political perspicacity of a very high order necessary to foresee that about 10 years will have to be used in the process of getting exhaust burners on all vehicles, new and already in use, unless they can be made at a cost not now predicted. All of which means that the current program will have achieved its goal just about in time to maintain the status quo for a brief period.

This is not an optimistic prospect; in fact, as a prediction, it will be quite unpalatable to many, and quite discouraging to all. In the context of my present discussion, it has very definite implications. It means that automobile exhaust not only is, but for a long time will continue to be, the major pollutant involved in Los Angeles smog. It means that the emission standards for automotive vehicles will have to be made more stringent. It means that every other contributory source of primary pollutants will have to be more and more rigorously restricted, especially those producing substances such as NO or NO_2, capable of reacting photochemically in combination with exhaust products. And it means that the battle against air pollution cannot finally be won so long as numbers of sources are increasing, just as the last schoolroom cannot be built so long as the number of students increases.

Perhaps it would be better for all of us now, or it will be a necessity in the future, to consider air pollution as a relatively minor but annoying symptom of the inherent malignancy of urbanization—overpopulation of limited areas. Polluted water, devastated natural resources, death by automobile, juvenile delinquency, mental illness, physical and moral decay are other symptoms. No one of them can be dealt with or even considered intelligently out of context with the others and with the monstrous growths from which they emanate. Even less useful is it to attempt to alleviate the one symptom—air pollution—by excluding all but one of its components from consideration. In some places, and at some times, one source may be of prime importance, but our cities grow and our problems change with time and with different points in space. It is much too easy to base immediate actions on the exigencies of next year's budget justification, or the necessities of biennial reelection. One can dream that some mechanism be established, well removed from the immediacy of political and economic myopia, to consider atmospheric pollution as a changing manifestation of a dynamic metropolitan complex, and to plan actions designed to cope with future as well as present circumstances.

As a biologist I am inclined to view manmade air pollution as a facet of nature's inexorable system of checks and balances. We have been endowed with no well-developed group capability for present action in the future interest of our species. When we foul our environment, three alternatives

ess over again, or we remain in filth until it overwhelms us and there is no new generation. In the first case, with time, the cost of maintaining a tolerable site eventually becomes so burdensome as to be itself intolerable and a population limit is thus imposed. In the second case the population limit is by choice; while in the third case the population limit is the product of inaction.

Of course you have sensed that I am about to conclude these loosely related remarks by appending a thesis I have never failed to set forth under some pretext since I first became interested in public health problems. So long as we have uncontrolled ... environment. It is easy to show that present levels of air pollution are generally proportional to population density even though dominant sources differ from one metropolitan area to another. Within rather broad limits the basic unit source of air pollution is one man.

This thesis is often countered with the view that any expectation of effective control at the real source is beyond hope. I suggest that any expectation of ultimate solution of our growing public health problems at any but this basic level is beyond possibility, even though palliative measures may carry us uneasily through a few more generations.

EFFECTS OF MOTOR VEHICLE POLLUTANTS

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I have been asked to cover a very large topic in a limited period of time and, accordingly, I can only highlight the major features of the extensive information that has been developed on these many-faceted problems. Publications, both original and review, have been increasing in number in recent years as interest and research have increased. Thus, there are available a number of excellent and up-to-date works outlining the present state of knowledge, and these should be consulted for further details and for full documentation.

I have taken the liberty of deviating somewhat from the area of discussion assigned to me by including in my comments the effects of air pollutants from sources other than motor vehicles. I have been obliged to do this for two reasons. First, an understanding of the effect of air pollutants from motor vehicles is very much dependent on the information available to us on the effects of contaminants from other emissions. Second, in most real situations air pollution comes from a number of mixed sources and it is quite impossible to allocate rigorously the observed effects to a specific origin. As noted by other speakers, motor vehicle emissions are normally major contributors to the so-called photochemical smog, and use of this term will generally imply such origin.

In dealing with the topic assigned to me, I will give most attention to the two areas of adverse effects of air pollution that have been examined the most extensively, namely, the effects on vegetation and on health. A related area, the general economic effects of air pollution, is certainly very important but the dearth of information permits only the briefest comment.

In respect to economic factors, it is apparent to the most casual observer that the general burden of air pollution on the economy is very substantial and unquestionably of sufficient moment in itself to provide adequate grounds for correction of the nuisance. That the costs are very great is quite clear; one very rough estimate for 1950–51 for air pollution from all sources was that the losses amounted to \$1,500 million per year in the United States; that is, about \$10 per inhabitant per year (*1*). A more recent statement notes that \$65 per inhabitant per year would be more reasonable (*2*).

It is, however, not possible at this time to make any really accurate appraisal of the cost to society of such factors as soiling and damage to clothing, household furnishings, stocks in warehouses, paint damage, and corrosion of stone and metals, which are produced by air pollutants from many sources. Obstruction of visibility and rubber deterioration are well known and costly consequences of photochemical smog, to which auto emissions are major contributors. Admittedly, the measurement of most of these factors will be difficult, in some cases impossible. This need was noted in a recent document prepared at the request of the U.S. Public Health Service, "National Goals in Air Pollution Research" (*3*), which recommended air pollution research needs in the next decade. This gap should be recognized and studies should be put under way aimed at developing efficient and effective means for assessing the economic costs of air pollution. Once such procedures are available they should be applied in a systematic way so that a running ledger on costs can be maintained. It seems quite probable that well based data of this sort can provide a most effective basis for the early institution of appropriate control measures.

By contrast with the uncertainties in this area there is a body of well established knowledge on the

cally signalled on this continent by several extremely vivid examples (4) of flagrant violations of the countryside by uncontrolled industrial discharges. Although there seems little likelihood that instances of equal intensity will be allowed to occur again, it has become incontestably clear that very significant damage to vegetation is occurring in many areas in this country by more typical and routine levels of air pollutants. "Smog" damage to crops is estimated to currently amout to some $8 million annually in California (5); motor vehicle emissions are unquestionably prominent contributors to these losses. Similarly, the cost of damage to agricultural crops in the eastern part of the United States has been estimated at $18 million; it is believed that this is mostly from ozone (6); again, auto exhaust should be suspect.

Research into the nature of the factors involved in the action of air pollutants on plants has been extensive and fruitful. In fact, the relationship between the concentration of air pollutants and the resulting plant injury has been sufficiently well defined so that plants show considerable promise as a means of measurement of air pollution.

Injury from air contaminants can involve nearly every kind of plants, whether these are wild or domesticated, ornamental or utilitarian, grown for pleasure or as a means of livelihood.[1] Although a large number of substances can damage plants, at the present time focus is on a relatively small group of substances. These include sulfur dioxide, fluorine, and, associated with motor vehicle emissions, "oxidants" and ozone.

The term "oxidant" covers a variety of unspecified air contaminants having in common the ability to reduce potassium iodide in neutral solution. Although ozone is a part of this complex, it is not predominant. The analytical procedure and the term have provided a very useful index for measurement of photochemical smog, characteristic of, and first described for, the Los Angeles air. It is, however, by no means restricted to either Los Angeles or to the west coast. "Oxidant" injury to plants is characteristically seen as a silvering, or glazing, of the lower leaf surface. This is typical of the plant (PAN).

Ozone, which is catalytically generated in photochemical smog, differs from "oxidant" in the nature of the injury produced on exposed plants; with ozone the upper surface of the leaf is attacked rather than the under surface. Exposures of a few hours at 0.2 part per million result in injury. As noted above, extensive damage to tobacco crops attributed to ozone has been reported in the eastern part of this country (6).

Detailed studies into the mechanisms by which plant injuries are produced by these various toxins are presently under way and should yield fruitful information. However, a more systematic evaluation of plant injury in this country than has been undertaken to date will be required if a valid assessment of the overall impact of plant damage on agriculture and the general economy of this country is to be achieved.

Turning now to the effects of air pollution on man, one first must call attention to the important contribution of air pollution to odors and to eye irritation; although these do not result in actual disease, they are nevertheless of widespread concern. Eye irritation occurs from a variety of irritant materials and is of particularly frequent occurrence in photochemical smog. Eye irritation in American cities is by no means limited to the west coast but is significant in major cities throughout the country. The specific materials in smog responsible for eye irritation are not definitely identified but probably include aldehydes, other oxidized hydrocarbons, and such compounds as PAN and nitro-olefins. Motor vehicles are major contributors to the production of these substances. The close correlation of annoyance with smog indices has been confirmed repeatedly (9).

As was the case with respect to damage to plants, public concern for the impact of air pollution on health is to a considerable extent traceable to major and dramatic episodes. In fact, had they not occurred it is conceivable that the major effort now under way to define the impact of air pollution on health would never have been undertaken. Motor vehicles were not of critical importance in these earlier incidents.

Two episodes in particular have become embedded in historical discussions of air pollution, one

[1] The following discussion of plant effects has drawn heavily on the excellent reviews in references (1, 7, 8).

occurring in Donora in 1948 leading to some 20 deaths (*10*) and another in London in 1952 (*11*), leading to an estimated 4,000 excess deaths. Periods of unusual atmospheric stagnation were linked with high, although not extreme, levels of contamination in both episodes.

Controls since instituted should lessen the likelihood of similar episodes in the future; nevertheless, where such controls have not been installed, or have been inadequate, the risk of major difficulties does remain, and another episode awaits only the recurrence of the required meteorological conditions to allow accumulation of lethal levels of toxicants. Fortunately, the particular set of meteorological conditions sufficient to produce the required circumstances is quite rare.

Of greater present interest than these major disasters is the extent of health impairment resulting from the more typical levels of air pollution found frequently in our major cities. At the outset it can be stated that this question is quite a difficult one, which for precise answers will require methods of a higher degree of refinement than have been generally undertaken in the past. One source of the difficulty in defining the health effects of air pollution results from the fact that there is no specific air pollution disease; that is to say, there is no particular pattern of symptoms that defines itself as having arisen from exposure to air pollutants. On the contrary, it is apparent that air pollution in its effects on health—and there is good reason to believe that there are such—acts primarily through the exacerbation of existing disease. Nevertheless, if air pollution introduced a major perturbation in the disease pattern it should be relatively easy to distinguish. Such a major perturbation has not been discernible to date, and perhaps we can conclude that air pollution is not a predominant source of disease in comparison to all other factors involved in disease induction, whether these be degenerative diseases, infectious diseases, or malignancy. One may further ask, since it takes such refined techniques to detect an effect, can such factors be important? The answer is clearly, yes; that is to say, a definitely significant, although not predominant, role of air pollution in disease causation may be present and still be difficult to measure. Included in the term "significant" here is the implication of such disease for the individual and for society. It will be useful to examine the evidence that is accumulating on this issue, as well as to consider current research, some still incomplete, which may give more decisive answers than are now available.

Two materials, carbon monoxide and lead, particularly associated with automobile exhaust, have been steadily increasing in concentration as community air pollutants in most cities in this country. Whereas only a few years ago, reported concentrations of these substances were far below levels regarded as significant for health, more recently each of these materials has been found in concentrations not too remote from the levels considered acceptable in industrial work places. Thus, carbon monoxide concentrations of 30 to 40 parts per million and lead concentrations of 20 to 30 micrograms per cubic meter are to be found in a number of regions of heavy traffic density (*5*). The industrial MAC's (maximum allowable concentrations) for these materials are 100 parts per million and 200 micrograms per cubic meter, respectively. Although the margin is still large, obviously, for a variety of reasons, more rigorous standards must be used with community populations than with industrial workers. Thus, community exposures are often superimposed on occupational exposures, individuals exposed to community air pollution may include individuals of all ages and of varying states of health and disease, and finally, exposures may be of longer duration.

With reference to these particular materials, there is no evidence at this time that health impairment does arise from such exposure; however, it will be important to establish more firmly the health implications of currently prevalent levels, and to guard against further increase in their concentrations.

Much attention has been given to the role of irritant chemicals in respiratory disease. Many materials appear to have in common the ability to produce irritation of the respiratory tract, individually and jointly. Such irritants have many sources. The combustion of sulfur-containing coal and oil produces sulfur dioxide and sulfuric acid. Motor vehicle emissions and the consequence, photochemical smog, bring their own constellation of irritants, including ozone, nitrogen oxides, and a group of oxidized organic compounds such as aldehydes, acids, peroxy acids, and so forth.

These materials may all produce irritation, which in turn may be the basis of interference with lung performance and the enhancement of disease.

shown that the inhalation of low levels of sulfur dioxide produce a definite increase in resistance to the flow of air in the respiratory tract (*12*). The impairment of respiratory function in these experiments is not to be interpreted as the production of a disease. However, in individuals with preexisting cardiorespiratory disease the additional respiratory burden may be a significant additional stress.

It is worth while also to note that similar experiments with guinea pigs show a decisive intensification of the effect of such irritants when otherwise innocuous aerosols are simultaneously present (*13*). Such intensification of effect is of practical significance since these irritant gases normally occur in association with particulates in the air.

Animal studies have been carried out on auto exhaust both with and without irradiation by sunlight or artificial sources. Most of this work has been done at concentrations of exhaust considerably higher than those found typically on heavily traveled streets. Recent studies are employing more typical concentrations and are examining a variety of responses to determine whether or not they are modified by the exposure (*14, 15*). Such a study showed an effect on spontaneous activity in mice; this had a threshold effect at approximately community pollution levels (*15*). Research of this kind has been in need of more sensitive procedures for evaluating the response of the experimental animals. Progress is being made in this area, making it profitable to extend research of this type to the examination of animal populations exposed to ambient air pollution. Such groups are to be compared to control groups living in purified atmospheres. Two such projects are now underway, one in Detroit and one in Los Angeles (*5*). These studies will extend over the lifetime of the experimental animals.

Studies have been underway for many years attempting to find whether or not there are temporal or geographical associations of air contamination with the health of the exposed populations. In general, as interest has grown and resources have improved, this research has increased in depth and sophistication. Only in a few instances is it possible

work required the consideration of many disturbing factors which could lead to fictitious correlations or, equally, conceal genuine relationships. A subsequent study by the same group revealed a corresponding increase in admissions to several hospital clinics for cardiac and respiratory disease during the same period (*17*). Although probably significant, the specific part played by motor vehicle emissions in these effects is unknown.

A study carried out in Los Angeles showed correlation of the attack rate of asthmatics with oxidant level but only at high oxidant levels, that is, at 25 parts per hundred million or above (*18*); automobile discharges are major factors in such levels of contamination. Similar consequences were observed with air pollution from different sources in an extensive study under U.S. Public Health Service auspices which involved a detailed examination of health and environmental factors in the Nashville area. This showed a correlation between sulfate concentration in specific areas and asthma attacks in those localities, as well as a correlation of sulfur dioxide concentration and time of occurrence of asthma attack (*19*).

An issue that has concerned many persons over a period of several decades is the possibility that community air pollution may contribute to cancer induction, particularly lung cancer. Many factors are no doubt involved in the development of lung cancer, including constitutional factors, external agents, and preexisting disease. It would not be surprising if air pollutants were shown to play some role in this disease, since respiratory irritants and carcinogenic chemicals are both present as contaminants in the air of our cities. However, here also the issue is unclear because the air pollution effect is neither overwhelming nor decisive. In this disease, as in some other respiratory diseases, the factor of smoking is of definite importance and, therefore, adequate allowance for the smoking history of individuals with lung cancer must be made in any statistical study aimed at determining the role of air pollution. A number of statistical studies have made corrections for this factor; these quite

generally show higher lung cancer rates in cities than in rural areas when comparisons are made on the basis of equal smoking intensity or when the comparison is restricted to nonsmokers. Such studies have been made both in this country and in England (*20–23*). It is very clear that the part played by place of residence is small in comparison to the importance of smoking. However, as noted, there is a clear trend showing somewhat higher cancer rates in urban dwellers after allowance for smoking. The small differences make precise statistical judgment difficult, and the issue is further confused by the fact that many other distinctions, for example, occupational exposures, conceivably could be responsible for these small remaining differences. Nevertheless, the suggestion of a relationship does remain.

It has been known for many years that carcinogenic materials are present in the air of cities. They are found in the exhaust of automobiles and in the combustion products of coal and oil. Such carcinogenic chemicals occur in higher concentration in cities than in the county. However, the levels found in cities in a recent study (*24, 25*) do not directly correlate with lung cancer rates in these cities. This need occasion no surprise, since other factors, as already mentioned, can play critical roles in determining these rates. On the other hand, a study in Britain shows such a correlation (*23*).

Although an interpretation is difficult, it would be a prudent assumption, still not proven, that community air pollution makes a significant, albeit secondary, contribution to lung cancer occurrence.

In summing up this brief examination of some of the effects of air pollution, the first point to be made is that a well-organized and coherent group of studies is now well underway. The last 10 years have shown vividly that crude tools are not adequate to give clear and sharp answers. Such tools have been improved and much research is now going forward that should place many of these issues on firmer ground.

One area clearly receiving inadequate attention at the present time is the development of procedures for assessing economic losses; this area badly needs increased effort.

In respect to plant damage, a first approximation of the overall impact is now available. Plant damage is unquestionably of major importance and reasonably clear-cut guides are at hand to aid in the focusing of appropriate control procedures.

The larger and more complex problem of human health effects from air pollutants is not nearly so well defined. However, a number of very strong leads suggesting association between air contaminants and disease is before us; moreover, extensive and careful research is now under way which gives indication of reinforcing these suggestions.

Although one cannot always clearly distinguish the role of auto emissions in these effects, plainly this source is generally significant and often predominant.

The clear import of the preceding observations is that there are many grounds for insisting that air contamination be reduced and that effective controls be maintained in the future. There are accessible a variety of approaches to these ends. One is through legislation, and legislation dealing with source control has been with us for many years. More recently California has pioneered in the development of community air standards as a basis for the regulation of emissions, particularly from motor vehicles. The extension of this latter approach is no doubt before us and the Public Health Service has an important obligation in developing the necessary background of knowledge for the wise establishment of such standards.

However, an informed public insistence on cleaner air is the most forceful and assured path and, in fact, legislation, no matter how wisely devised, is likely to be ineffective if not backed by the public. In informing the public, objective and solid evidence will be the best basis for insuring a balanced and durable control program, and we should give full support to the Public Health Service in its energetic development of this foundation of knowledge.

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It is a pleasure to represent the automobile industry on this panel of the National Conference on Air Pollution. We are particularly pleased with the theme of this Conference, "Let's Clear the Air," because, as the result of many years of concerted effort, the automobile industry's new products are equipped with devices for the express purpose of helping to "clear the air." Thus, for the first time, we are able to address a national audience of this stature not only in terms of research and progress and status of device development, but also in terms of factual accomplishments. Crankcase emission control devices have been developed and now are on cars. These control devices now are assisting in "clearing the air."

When we were invited to address this Conference, it was suggested that we concentrate on how future automotive design may affect automotive emissions. This will be covered in due course. First it is desirable to discuss the past and the present, since many of you, after viewing our industry's research and development programs in Detroit, have expressed amazement at the extent and diversity of our efforts to reduce emissions, and then have criticized us for not making the magnitude of our programs better known. We also believe a brief review is important in order to establish the basis for our speculation regarding the future.

The industry's formal program began over 10 years ago, when the photochemical smog problem in Los Angeles was defined by Haagen-Smit. At that time, consultations with experts and on-the-scene investigations convinced our industry that automobiles might be an important factor. The industry marshaled its efforts under the auspices of the Automobile Manufacturers Association (AMA). A fundamental program to define the role of the automobile in the formation of photochemical smog was initiated and continues today. As a portion of this program, instrumentation was developed and applied to determine the extent of the automobile's contribution to photochemical air pollution. In addition, programs aimed at developing control measures and devices were initiated. As part of this effort a cross-licensing agreement was signed by the AMA member companies so that solutions would be made available on a royalty-free basis to all of the automobile manufacturers.

Initial investigations convinced us that inadequate data were available for defining the emissions from automobiles. To obtain this information, traffic surveys were conducted with the help of public agencies to determine how cars are driven. Using these driving patterns, field surveys were then conducted to measure the exhaust emissions from a large number of representative cars. The data from both the traffic and the field surveys have been used in formulating the current California Exhaust Standard. In addition, the instrumentation developed for the field survey has also been incorporated in the California Exhaust Standard.

With the more adequate definition of the vehicle emission problem, it was then possible to reevaluate our control device program and select approaches on a sound basis. In this effort, literally hundreds of proposed solutions were developed and evaluated. Out of all of this activity nothing changed one fact that emerged clearly very early in the industry program: control of automobile exhaust emissions was going to be far more difficult than simply attaching a gadget to a tailpipe.

The efforts of the automobile industry and other allied industries in seeking solutions to the automobile emissions problem are well documented in

modification is receiving energetic attention. To our knowledge no automobile exhaust-treating device has been developed to the point of commercial application although several devices are undergoing test and evaluation in California and in Detroit.

The crankcase emission problem has been successfully resolved. The history of this development is most interesting. Originally it was thought that crankcase emissions were an unimportant source of hydrocarbons. A few years ago, however, the industry used its newly developed instrumentation to assess the relative importance of crankcase emissions. It was indicated that crankcase blowby gases accounted for approximately 40 percent of the total hydrocarbons emitted from well-maintained automobiles.

The automobile industry moved quickly when it discovered the importance of crankcase blowby gases. In November of 1959 it was announced that all 1961 model American-made automobiles sold in California would be equipped voluntarily with positive crankcase ventilation systems to eliminate effectively the crankcase as a source of hydrocarbon emissions.

In this instance the industry was able to move quickly because the solution was simple, and involved applying systems which had been used for many years for crankcase ventilation in special applications. Experience with these devices in California and in special test fleets elsewhere uncovered some minor operating difficulties. Performance was deemed sufficiently satisfactory, however, that when the U.S. Department of Health, Education, and Welfare stated that installation of blowby devices on a nationwide basis would be beneficial, the industry was ready. In December of 1961, it was announced that 1963 American-made gasoline-powered vehicles would be equipped voluntarily with positive crankcase ventilation systems on a nationwide basis.

After 10 years of effort the 1963 products of the automobile industry illustrate the theme of this Conference, "Let's Clear the Air." The 1963 models in the dealer showrooms and in the hands of the public are equipped with a device to reduce hydrocarbon emissions by nearly one-half. It should be further noted that in both cases, for California cars in 1961 and for nationwide production of 1963 models, the industry has taken action volun-

Thus far we have talked mainly of the program of the automobile industry aimed at achieving control of vehicle emissions. I think it equally important to examine the efforts being made to define the relative importance of these emissions in the specific air pollution problems of individual communities. The State of California is to be commended for the pattern it has established both legislatively and technically in its efforts to "clear the air." The pioneer work of the Los Angeles Air Pollution Control District is well documented and deserves the credit it has earned. The California Legislature is to be commended for its farsighted approach. As a first step, it directed its department of health to establish air quality standards to define "clear air." It also directed the department to establish emission standards for automobiles which in concert with standards for other sources of emissions would result in "clear air."

To provide for meeting these emission standards, California Assembly bill AB–17 (1960) established the Motor Vehicle Pollution Control Board and directed it to set performance and other criteria for emission reduction systems and to certify those systems which meet all the standards and criteria. The bill also established a compliance timetable for installation of certified devices on new and used cars and provided for exempting those vehicles which meet the vehicle emission standards without additional equipment, or for which there is no certified device.

By the foregoing actions, California has established performance criteria and passed performance legislation, properly leaving to industry the freedom and responsibility to design the best possible means of emission control. In the industry's experience, performance legislation has proven more beneficial to the public than arbitrary design legislation.

We sincerely recommend that other States or municipalities study carefully the California methodology for handling control of its air pollution problems. First define clean air, then determine by measurement if a problem exists, evaluate the sources of the contaminants, and establish performance criteria for control of these sources.

The U.S. Congress, and particularly the members of the House Public Health and Safety Committee, are to be commended for their efforts in the air pollution field. By legislative direction and by

appropriation of necessary funds, the Congress has made it possible for the Public Health Service to step into the air pollution problem in a vigorous manner. While many of its projects are only in the beginning stages, the results obtained from its air monitoring network are helpful to communities in defining their own air pollution problems. Its smog chamber studies should be useful in determining the degree to which automobiles and other emission sources should be engineered to achieve "clear air." More importantly, its many programs to determine the effects of various types of air pollutants on health should result in a much clearer definition of the specifics of the total problem. All of these programs and the many others I have not mentioned are important and necessary if the control of air pollution is to be carried out in an effective and economically sound manner.

Now, what about the future? A new dimension has been added to the design of automobiles. Engines in particular have always been evaluated on the basis of three fundamental criteria: cost, performance, and fuel economy. Many other parameters are involved, of course, but these three have dominated. Now automotive engineers are assessing new engines and vehicle designs by a fourth criterion—vehicle emissions.

Assessment of this new dimension has, interestingly enough, established that vehicle emissions are related to a considerable number of aspects of engine-vehicle design. For example, leaner carburetion to improve fuel economy has been found to reduce vehicle emissions. Automatic transmissions reduce hydrocarbon emissions during deceleration. Improvements in component durability to increase reliability and to reduce the need for maintenance can also contribute to lower emissions.

The continuing research programs on new types of engines have been augmented to include evaluation of exhaust emissions. Since most of these engines are still in the early experimental stage, the primary research efforts are concentrated on achieving satisfactory operation throughout the required speed and power range. Exhaust emissions data are acquired during each stage of development and are considered in the step-by-step design changes. Data acquired during the development program are not fully definitive. Such definitive data can only be obtained on production engines.

Even if a new engine type which had lower emissions than current engines was fully developed today, the time required for production engineering and tooling would prevent its appearance on new cars for several years. Of more immediate importance is the reduction in emissions that can be achieved by modification of the operating and design parameters of engines currently in production. As mentioned previously, work on engine modification is receiving vigorous attention within the industry, and may result in lower emissions from current engine types long before any novel engine concept will be available.

It is well known that any product in the hands of the consumer must be maintained within the manufacturers' recommendations if it is to continue to perform properly. This maxim can be applied especially to vehicle emissions. While all the data are not yet in, indications are that gains in emission control, whether achieved by new design or by control devices, will go for naught unless a continuing maintenance program is followed.

History has shown that the average user is lax in maintaining the engine components related to exhaust emissions at near-peak performance. There is no reason to believe that user habits will be changed even though proper maintenance may be emphatically advocated by the authorities or the industry.

The automobile industry therefore urges all communities or States that have an air pollution problem in which automobile emissions are a major factor to consider the benefits to be derived from a vehicle maintenance and inspection program.

Reduction in vehicle emissions from this approach in combination with the reduction in emissions by positive crankcase ventilation systems may be sufficient for most communities where automobiles are a factor in the air pollution problem. A program of regular vehicle maintenance should also result in the added benefits of improved vehicle performance and increased miles per gallon.

We recognize that the program just detailed may not be adequate for all communities. Through its research programs and publication of many technical papers, the automobile industry has stimulated a broad and intensive effort throughout American industry to find effective and economic exhaust-treating devices. California now is testing several different devices to see if these will indeed be effective and economic solutions to California's problem. The automobile industry is working with California as closely as possible, and we are vitally interested in the outcome of their current test and evaluation

studies. Concurrent with California's program, we are continuing our program for achieving maximum control at minimum cost to the public.

Let me now summarize the status of the overall program for controlling automotive emissions. The automobile industry has recognized and accepted its responsibilities and is carrying out a broad technical program directed toward producing vehicles which do not pollute the air. The State of California has performed pioneer work in the fields of both technology and legislation in order to achieve its goal of returning clear air to California. The U.S. Congress has recognized the growing problem of air pollution from all sources and has provided the necessary directives and funds to enable the Public Health Service to step up its efforts. Industry in general has been quick to respond in applying available control methods. The automobile industry has been able to take a major step forward by incorporating in the 1963 models positive crankcase ventilation systems.

Finally, I would like to leave you with certain principles and recommendations which our industry has adopted after careful study of the air pollution-vehicle emissions problem.

1. The automobile industry recognizes and accepts its responsibilities with respect to the contributions from vehicles to air pollution.

2. The automobile industry will apply control measures when they have been proven to be effective, economic, and needed.

3. The automobile industry offers its continued assistance to all agencies concerned with the air pollution problem.

4. The automobile industry suggests that maximum progress can be made in communities by—

a. thorough evaluation of community air quality;

b. careful evaluation of the magnitude of emissions from each source;

c. control of emissions by establishment of performance standards rather than design standards; and

d. establishment of a maintenance and surveillance program in conjunction with required source control.

PUBLIC POLICY IN MOTOR VEHICLE POLLUTION CONTROL

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I am very pleased to have the opportunity to discuss the topic of "Public Policy in Motor Vehicle Pollution Control" at this National Conference on Air Pollution. As a native of Dayton, Ohio, I have grown up and lived in a community whose name is immediately identified with such engineering trail blazers and geniuses as Orville and Wilbur Wright and Charles F. Kettering, and where industrial enterprises associated with mechanical vehicles have flourished. I have grown to have the utmost respect for and confidence in the mechanical know-how which that community typifies for the country as a whole. If a reduction of pollution from motor vehicles is necessary, I know that, within our industry, the capabilities exist to reduce it to whatever degree is required.

Should pollution from motor vehicles be controlled? If so, how, to what extent, and by whom? The control of vehicular emissions presents problems. On the other hand, failure to control them also brings on problems.

The time has arrived when public policy on this question needs to be clarified. Is a national policy required or can satisfactory solutions be achieved by decisions of the 50 individual States? Our two most populous States have already passed legislation which will require control devices, and it is quite evident that other States will follow their lead, particularly as such devices are developed which meet the prescribed criteria. The question, therefore, is no longer merely academic.

Let me propound a number of questions. (1) Is there really a need to control automotive pollution? (2) If so, is control necessary throughout the country? (3) If not, why burden every car owner with additional expense? (4) What alternatives for control are there to attaching afterburners or other devices on cars? (5) Should responsibility for developing vehicles which produce less pollution rest within the automotive industry? (6) If not, who should pay for research in this field? (7) If a type of engine should be developed which does not pollute the air, should the present type of engine be prohibited? (8) Should additional mass transit facilities be developed as a means of reducing air pollution?

These are merely examples of the kinds of questions which must be resolved in developing a public policy on motor vehicle pollution control. The socioeconomic implications and ramifications associated with the answers can be enormous.

No one person can provide the answers to all of these questions. In the short time available, however, I merely want to consider some of the factors involved, with the hope that this will help stimulate discussions necessary for the development of public policy.

Six months ago, the Surgeon General submitted to Congress a report entitled "Motor Vehicles, Air Pollution, and Health." This report was prepared in accordance with the provisions of Public Law 86–493, an act which I had the honor of sponsoring. The report, now available to the public as House Document 489, presents a most noteworthy review of the sources, types, and amounts of contaminants discharged by vehicles, the chemistry of their behavior in the atmosphere, the state of knowledge about their effects on health, and the possibilities for effective control of pollution through various methods which have been proposed.

The report makes several points very clear. One is that air pollution constitutes a significant and

despite the fact that automobile manufacturers are including "blowby" control systems as standard equipment on all new cars, starting with their 1963 models, and to become worse even if exhaust control devices which meet the California requirements should soon be at hand. This gloomy prospect confronts us because, with the ever-growing increase in the total number of cars, the total amount of pollution is likely to continue to increase for some years even though the individual new cars may discharge less than the present ones. Some progress has been made in developing control devices for new vehicles despite technical and economic difficulties. These problems are intensified for used cars, since older cars are likely to discharge more pollution and since the installation costs for controls will be higher than they would be if controls were put on at the factory.

In the early days of our Nation, when our population was small and thinly dispersed, little attention was given to the disposal of liquid wastes, and none to those which were airborne. As the number of people and industrial development increased, particularly in cities and towns, the need for sewer systems, and later for sewage treatment plants, became recognized and accepted. Today the need to maintain the quality of our water resources goes without saying.

It is at least equally vital to maintain the quality of our air resources. Perhaps more so, for man can survive for limited periods without water or food, and can take emergency measures to purify those items if necessary. He cannot live more than a few minutes without air, however, and there is no simple procedure—like boiling his water, for instance—to remove the impurities.

So we have finally, if somewhat belatedly, come to realize that our air resources are not limitless, and that a growing population and a remarkably expanding technology are placing a demand upon these resources which cannot be ignored. Consequently, we have seen, particularly in recent years, the imposition, by State and local governmental agencies, of certain restrictions on the discharge of contaminants into the air. The restrictions around the country have not been consistent as to kind or severity, and the reasons for this are readily under- with an utter disregard for the effects these actions might have on the air our fellow citizens must breathe.

While satisfactory control of air quality is far from accomplished in many localities, methods for coping with most of these problems are known, and will be applied eventually as the interests of the community dictate. We know, for example, how to reduce smoke emissions from furnaces by appropriate fuel modifications and firing practices. We have a variety of collection devices to trap dust, and scrubbers to remove noxious gases. These tools we have, in practicable form, for most stationary sources of pollution.

The motor vehicle, however, presents a different kind of problem. Here we have a pollution source which is highly mobile, which discharges contaminants in a variable manner, and for which satisfactory control methods are not yet available. And in what numbers we do have this source! Do you realize that the number of motor vehicles in the United States discharging pollution into the air probably far exceeds the total number of all other sources combined, including the chimneys and stacks of every home, factory, commercial establishment, and public building? It is no wonder, therefore, that we have a need to look into this problem at a national conference of this type. Like it or not, we must face up to the fact that the time is here when concentrated efforts of appropriate scope and magnitude are needed.

The automotive industry has made some commendable efforts on this matter thus far. The Federal Government likewise has looked into the subject, as I have previously mentioned. Universities and other research establishments have also made contributions.

By and large, however, with the exception of the State of California, none of us have adequately acknowledged our responsibilities. The scale of work done has been pitifully small, although the lure of a lucrative market for control devices in California has stimulated industrial research of a limited character.

Who has the responsibility for air pollution from motor vehicles? Is it the industry which produces

them? Is it the public which uses them? Or is it government which does or does not regulate them? As I see it, all three must share this burden and work to improve the situation.

I have chosen to mention industry responsibilities first because, despite the clear and considerable responsibilities of all levels of government and the public, it is quite apparent that those who design motor vehicles are in the best position to deal with the problems of auto exhaust. We know enough about the problem of auto exhaust to discern a clear need for the development of motor vehicles which will help clear the air.

One approach is through the addition of some type of device which will correct the deficiencies of existing engines by destroying the pollutants which would otherwise escape. This is the avenue currently being used by most manufacturers who are looking for ways to enable California motorists to meet State requirements. It is my understanding that, although encouraging progress has been made along these lines, no device has yet satisfied all of the California performance standards. I shall be very pleased when and if acceptable devices of this class become available. I doubt, however, that the general public will be completely satisfied with this kind of answer to the vehicular pollution problem, since it involves the addition, with consequent extra cost, of something which is not basically part of the car, and something which will probably require periodic inspection to insure that it is functioning properly. While these devices appear to offer the best help for the immediate future, I hope intensified efforts will be made to produce engines which do not need such attachments, but which cause less pollution because of more efficient operation.

Motor vehicle manufacturers, in their highly competitive business, are constantly striving to produce more attractive cars with better performance characteristics. I would hope that they now recognize the reduction of emissions as a performance objective which is at least as important as acceleration capabilities. This will not be easy, but I am confident that it can be done. I have a suspicion that if the registration costs for vehicles were directly related to the volume of products of incomplete combustion in the exhaust gases, remarkable progress might result!

I do not know whether automakers can solve the pollution problem through minor changes or whether radically different engines will be needed. I do not doubt, however, that American industry can produce whatever is needed, and will do so as required. This confidence stems from our experience over a number of years on other problems of concern to the Subcommittee on Health and Safety of the Committee on Interstate and Foreign Commerce in the House of Representatives.

The individual car owner has a responsibility to maintain his vehicle in a good state of repair. The necessity for properly functioning brakes, for suitably adjusted lights, and for windshield wipers and horn in good working order, is well recognized, and is required by law in many States and communities which have periodic inspection. The car owner also has a responsibility, not yet widely acknowledged, to keep the engine in proper condition so that pollution due to faulty ignition and excessively worn parts will not result. There are some authorities in the automotive industry who believe that the California emission standards can be met merely by proper engine adjustment and maintenance. The cost of such maintenance is offset to a considerable extent by reduced fuel conusmption, and by the satisfaction and pleasure of driving a car with good performance.

Government must do more to meet its own responsibilities in reducing vehicular pollution. At State and local levels it should take steps as needed to keep the bad pollution producers off the road. At the national level it should exert vigorous leadership in many ways. It should stimulate and encourage industry efforts to produce cars which do not pollute the air so much, if at all, and should supplement such efforts with investigations of its own on the relationships of design principles to emissions, and with support of research by engineering schools and other competent agencies. It should also inspire and support additional research which will shed light on the questions of what pollution does to human health, to vegetation, and to property. It should develop criteria to serve as benchmarks for those who design and build engines, as well as for those who must design and apply regulations, with further provisions to make sure that travel from one State into another does not impose further legal complications. Also, I feel that the Federal Government should find or develop mechanisms whereby promising new ideas, frequently produced by individuals with meager resources, can be examined and tested without undue delay and expense.

public itself is intimately involved with respect to both cause and effect. It is fortunate, therefore,

can tradition, so that suitable foundations for a sound public policy can be built.

Prepared Discussion: THE RATIONALE OF MOTOR VEHICLE POLLUTION CONTROL

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The control of motor vehicle emissions is a recent undertaking in man's attempt to prevent the pollution of the atmosphere of his communities. In California the decision was made several years ago that air pollution in that State's metropolitan areas cannot be solved without the control of air contaminants from motor vehicles. It is likely that other States or areas have already reached or will reach the same conclusion.

As is to be expected, this effort involves many problems and approaches that are different from those commonly associated with the control of nonvehicular pollution. It is important that programs to control air pollution created by motor vehicles recognize the elements associated with this problem and make provisions for appropriate technical, legal, and administrative means to deal with these elements.

Many of the distinctive aspects of the motor vehicle pollution problem are immediately apparent. Vehicles are present in very large numbers, they are widely distributed, they are mobile, and they freely cross political boundaries. They are not subject to continuous or frequent inspection, as is the case for smoke from a stack. It is worth noting that motor vehicle emissions are highly variable. Also, pollutants are discharged from more than one point in each vehicle and different methods of control may be needed for each point. It therefore follows that the control of pollution from motor vehicles requires the development of new methods, legislation, and emission standards. An interesting sidelight is that the installation of control devices on vehicles will extend air pollution regulations more directly to the individual than has been the case in other air pollution abatement activities.

As in the case of the stationary sources, the control of motor vehicle emissions must take into account the nature of the problem that exists in the community and the steps required to solve it. This in turn requires dependable data on the air pollution effects, the atmospheric concentration of pollutants, the role of the motor vehicle pollutants in the total air pollution problem, and the quantity of pollutants from both vehicular and nonvehicular sources. It is also important to decide the air quality that is to be maintained or achieved. This information is necessary for the development of the technical programs as well as for the legal and administrative decisions that must be made.

Because motor vehicle pollution control is a new development, its rationale cannot be discussed in reference to the experience gained from time-tested programs. However, information and interest on the subject have developed rapidly and the State of California, after more than 10 years of study, has undertaken a comprehensive program aimed at bringing about a large reduction in the quantity of pollutants now discharged from motor vehicles. A description of steps taken in California and the reasons for them will illustrate the thinking in that State and will point out many of the factors that must be considered by anyone attacking this problem.

Laboratory and field investigations carried out over a period of years show that motor vehicles are a major source of the contaminants responsibile for the air pollution problem in California. In the Los Angeles area, motor vehicles contribute over 90 per-

two-thirds of the oxides of nitrogen because space heating, another source of these compounds, is at a minimum in warm seasons.

In most of the larger communities of the State, the relative contribution of carbon monoxide, hydrocarbons, and oxides of nitrogen from motor vehicles is similar to that in Los Angeles. At the present time the motor vehicle is of lesser relative importance in the San Francisco Bay area only because the control of stationary sources in that area is not as advanced as that in Los Angeles. This is a situation that is rapidly changing.

In considering what measures should be taken, one of the most important decisions which had to be made in California concerned the level of government that would be given the responsibility for a program to control emissions from motor vehicles. It was decided that it was not practical to undertake this activity at the local level and that such a program could best be carried out by the State. This decision took into account that there is a large number of vehicles; that they are widely distributed; that they are a common and major source of air pollution in the larger cities of the State; that they freely cross local political boundaries; and that they are already regulated and taxed by the State level of government. It was also recognized that several different motor vehicle pollution control programs in one State would be confusing and difficult to enforce.

One of the first steps taken was the enactment of legislation requiring the State department of public health to establish air quality standards and motor vehicle emission standards (*1*). This was done in 1959. The air quality standards serve the purpose of defining air quality in California communities and providing a basis to determine the degree of motor vehicle emission control required. The standards for emissions from motor vehicles in turn are for the purpose of defining the quantity of pollutants that will be permitted from motor vehicles.

The department of public health has adopted air quality standards on several pollutants. Two, carbon monoxide and "oxidant index," have a direct bearing on emissions from motor vehicles. From the air quality standards and other information, the department of public health adopted motor vehicle all sources and the concentration of pollutants emitted by the vehicle, and extrapolation of the data to a reasonable time period in the future. The year 1970 was selected.

2. Evaluation of current levels of atmospheric pollutants, those expected in 1970, and levels in the air quality standards which describe the relationship of air pollution effects and concentrations.

3. Calculation of the necessary reduction of pollutant emissions to maintain the desired air quality. This procedure indicated that motor vehicle hydrocarbons should be reduced by 80 percent and carbon monoxide by 60 percent.

A description of the carbon monoxide standard will illustrate this approach. The air quality standard for carbon monoxide is 30 parts per million for 8 hours. Air monitoring data for Los Angeles indicated that the standard had been exceeded on a number of occasions. It was known that motor vehicles were responsible for over 90 percent of the carbon monoxide in the atmosphere. The needed reduction and allowable concentration in vehicle exhaust were calculated from predicted vehicle population and atmospheric concentrations of carbon monoxide in 1970 and data on the concentration of carbon monoxide in the exhaust.

The standards for air quality and motor vehicle emissions provide a technical basis for motor vehicle emission control. An actual control program requires legislation to implement the standards. This was accomplished in California by a State motor vehicle pollution control law providing that vehicles registered in the State shall have approved control devices after two or more devices have been certified (*4*). A schedule was included for compliance by both new and used vehicles. Both groups of vehicles had to be considered because in areas with a serious problem an early solution requires the control of emissions from a large majority of the vehicles. New car sales each year represent about 10 percent of the total registered vehicles; many cars in regular use are over 10 years old.

The California law created a Motor Vehicle Pollution Control Board with the responsibility to

approve devices after its tests show that the devices meet the motor vehicle emission standards. Before certifying a device, the Board must take into account its cost, safety, reliability, ease of inspection, and other aspects that are in the public interest. The Board also has the authority to exempt classes of vehicles from the requirement that they have control devices.

All new vehicles are required to follow a schedule for installation of approved devices, but local boards of supervisors in each county decide if the devices are to be installed on used vehicles in each county. This provides for rapid implementation of the control program in counties where serious air pollution exists, and a modified program in other counties.

The program that has been described is not the only possible approach, and those planned by other areas may not be similar to that in California. They will have their own characteristics, reflecting their own needs. But all of them will have to take into account most of the factors that had to be considered in California.

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CONTROL—THE STATE VEHICLE ADMINISTRATION

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Few automotive developments in recent years have received the attention that has been directed to California's efforts to eliminate motor-vehicle-created smog. Every step of this pioneering undertaking has made news and has been recorded in detail in the public prints. No doubt this expanding interest in an unusually complicated problem stems in part at least from the realization that air pollution is not confined to California alone. A recent report of the U.S. Public Health Service reveals that air pollution arising from automobiles is spreading throughout the country and holds a potential threat to life and property. Small wonder then that California developments are being watched so closely!

Many of the writings so far have been directed to the actions of the Motor Vehicle Pollution Control Board created by the California Legislature in 1960. The Board, dedicated to returning the quality of California air to 1940 levels, has proceeded with care and discretion in setting the requirements and criteria to be followed by manufacturers of control devices.

For both crankcase and exhaust devices, the Board has established requirements for longevity, cost, effect on engine operation, safety, heat, and ability to operate in the wide variety of driving conditions found in California. But perhaps the most troublesome problem of all, that of enforcement and compliance, is still to be solved. It is in this field that the Department of the California Highway Patrol and the Department of Motor Vehicles will exercise their legally constituted responsibilities.

The Commissioner of the California Highway Patrol and the Director of Motor Vehicles are ex officio members of the Motor Vehicle Pollution Control Board and both are members of the Board's Committee on Enforcement and Compliance. The Highway Patrol Commissioner serves as chairman of the committee.

At this writing the Committee on Enforcement and Compliance is developing a workable program to control both the installation and the effectiveness of continued operation of both crankcase and exhaust devices after certification by the Department of Motor Vehicles. The Enforcement and Compliance Committee is leaning toward a statewide complex of licensed, privately owned and operated inspection stations, but a final decision by the Board has not been reached.

The Motor Vehicle Pollution Control Act provides that enforcement shall begin 1 year after the date of certification for two or more motor vehicle pollution control devices. The certification date for crankcase devices, for new cars only, has been established as April 26, 1962. Enforcement at this stage of the operation of the law has not been difficult, for two reasons:

1. Crankcase devices are installed by the manufacturers of all American-manufactured vehicles.
2. It has been the Board's belief that periodical service of these units need not be made mandatory.

Crankcase devices for use on used vehicles, as of this date, have not been certified by the Board. I

personally believe that the Board will certify crankcase devices for used cars some time in December of this year.

A certification date for exhaust control devices is yet to be established, since testing is still underway. Because of the time involved in testing, it is unlikely that a certification date will be established before the summer of 1963.

The present Motor Vehicle Pollution Control Act is concerned only with the initial installation of an air pollution control device. The law itself does not specify the type of device nor does it say anything about an inspection, annual or otherwise. It seems evident, however, that the purpose of the law would be defeated if an inspection of some type is not required. Catalytic exhaust devices have a life limited by the operative term of the catalytic agent and afterburner exhaust devices require inspection and adjustment periodically to operate at peak efficiency.

The law provides that no new motor vehicle shall be registered in California after 1 year from the certification date unless and until it is equipped with a certified device. It further states that no used motor vehicle upon transfer of registered owner shall be registered after 1 year from the certification date when the principal location for the motor vehicle is a county or a portion of a county where the provisions of the Motor Vehicle Pollution Control Act are operative, unless and until the motor vehicle is equipped with a certified device. Furthermore, no used commercial motor vehicle shall be registered after the second December 31 next following certification date when the principal vehicle location is a county or a portion of a county wherein the provisions of the act apply, unless and until it is equipped with a certified device. Finally, no motor vehicle is to be registered after the third December 31 next following the certification date when the principal vehicle location is a county or a portion of a county where the act applies, unless and until it is equipped with a certified device.

It can easily be seen from the above that there are multiple factors to be taken into consideration by the motor vehicle administrators in addition to the normal requirements in registering a vehicle in California after devices are certified. In the case of new automobiles, the procedure will be fairly simple. Since all new vehicles, whether or not they are sold in a smog area, will be required to have the device installed one year after the certification date, all that will be required will be a certification of installation on the dealer's report of sale. A windshield sticker or other suitable indicia would be affixed to indicate the presence of the device and the date for inspection.

When used cars are considered, however, the problem becomes more complex. The requirement that they be equipped with devices will depend upon whether or not their principal location is in a county which has been exempted by action of its governing board from the provisions of the act. In this instance, a further administrative problem has been created for the Department of Motor Vehicles in that it must make a determination as to whether a particular used motor vehicle is entitled to the exemption. Once the determination is made and the records of the department are established, they will always be subject to change according to the mobility of the registered owner. His change of residence from an exempt county to one included in an air pollution control district will require installation of the device.

The thinking of the Enforcement and Compliance Committee in regard to installation of devices on used vehicles leans toward a staggered installation schedule in order that inspection dates would not all occur at the same time. It has been suggested that the time of year for installation of a device on a specific vehicle shall be determined by the last digit of its license plate. Upon installation of the device, a windshield sticker or other indicia would be affixed to the vehicle, indicating that servicing of the device would be required 1 year later. Details of the sticker have not been presented to the Board but it is contemplated that it would have a distinctive color for the year of issue and would bear the month and year of expiration in order that enforcement officers might readily determine if the vehicle is equipped with an effective device.

It is also contemplated that in addition to the windshield sticker, there should be a distinctive code entry on the registration card indicating the presence of the device, and a certificate, to be kept with the registration card, attesting to the installation or inspection of the device. The latter upon presentation would serve to eliminate the need for physical inspection of the vehicle by Department of Motor Vehicles' clerks if the vehicle is transferred to a new owner.

For purposes of law enforcement and compliance to standards set forth by the Motor Vehicle Pollution Control Board, it is necessary that one State

be the Motor Vehicle Pollution Control Board but inasmuch as it lacks staff to undertake such an ambitious program, statewide agencies such as the Department of Motor Vehicles and the California Highway Patrol seem indicated. The chairman of the Committee on Enforcement and Compliance has indicated his willingness to have the Department of Motor Vehicles conduct the program.

If the Department of Motor Vehicles ultimately is selected to administer the installation and inspection program, it will propose the following:

1. The form of authorization for an establishment to engage in installation and inspection of air pollution control devices will be a license granted by the Department of Motor Vehicles. The detailed content of the license will be determined when the control program is more advanced.

2. An adequate number of installation inspection stations to fulfill the needs of the initial year of control will be licensed prior to the enforcement date or shortly thereafter. The best possible dispersal over a wide area will be sought.

Studies conducted by the Department of Motor Vehicles show that a minimum of 124 inspection

spection rate of five vehicles per hour, it does not take into account the need for greater geographical distribution as a convenience to the motoring public. The actual figure, therefore, would be considerably greater.

From the statements thus far recited it can be deduced that the problems of motor vehicle administration in the smog control problem are multiple and some still remain to be solved. Actually, only a few of the problems have received the consideration of the full board membership and no definite program of enforcement and compliance has been adopted.

Many hours have been spent on discussion and planning of this phase of California's program and it is anticipated that the board ultimately will adopt the committee's program for enforcement and compliance. The committee members hopefully anticipate early action, since some of their suggestions, notably those establishing official testing stations, permitting issuance of certificates by these stations, and prohibiting operation of a motor vehicle required to have a device without an appropriate windshield sticker, will require legislation. In order to meet schedules which now appear likely, it will be necessary for appropriate legislation to be adopted in 1963.

Prepared Discussion: PROBLEMS OF ... CONTROL—THE MOTORING PUBLIC

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Everybody wants clean, fresh air to breathe and to live in. Consequently, no one wants air pollution. But of course the problem isn't that simple. Evidence from several serious air pollution episodes, from certain cities, and from other sources shows that air pollution is a matter which warrants the most serious attention of the American public, and calls for positive rather than negative viewpoints and approaches. This conference is a commendable project.

It is encouraging to note the great emphasis which is placed on getting the facts as a basis for dealing with this important and growing problem. Surely the greatest need, from the point of view of making substantial and continuing progress, is for greatly increased study and research. In this connection, I would assume that there is continuing validity and importance to the report of the distinguished task group set up by the Surgeon General. I refer to its report, submitted in 1960, entitled "National Goals in Air Pollution Research." One could not help being impressed with these recommendations, including one which called for multiplying by three the annual expenditures devoted to air pollution research by 1968. Let's hope that the 10 principal research goals listed in that report are receiving due attention and appropriate financial support.

Research, particularly in Los Angeles, has established that, when in operation, motor vehicles produce considerable amounts of gases, fumes, etc., which then become part of the air pollution picture. But this is not to say that motor vehicles in your city or mine are important factors in producing a serious degree of air pollution. Indeed, in most places, the conditions essential to development of serious air pollution have not been shown to exist simultaneously in dangerous degree. From a practical viewpoint, the extent of air pollution present from time to time is the matter to be faced—along, of course, with any trends which show changes in the degree of air pollution.

It is generally agreed that troublesome urban air pollution requires two factors: (1) substantial amounts of pollutants in the urban air; and (2) insufficient air movement to dissipate the pollutants fairly promptly. In the Los Angeles type of smog, two other factors are necessary; (3) a temperature inversion whereby a warmer layer acts as a cap or lid over the basin in which the city lies; and (4) sunlight, which produces a photochemical reaction that alters some of the pollutants unfavorably.

In connection with No. 4, a very important further factor, often overlooked, must also be present, and that is time—there must be sufficient time during which these conditions exist, because the photochemical reactions require a fairly substantial amount of time.

These points are presented to emphasize that air pollution is a complicated matter, and unless the subject is viewed objectively and comprehensively, there is a very real danger that some people will give undue emphasis to individual factors in the picture.

Turning now to the motoring public, it should be pointed out at the outset that the motoring public is a very large proportion of the American public—with three out of four families each owning at least one motor vehicle. It should also be borne in mind from the outset that Americans like

family investment. Their numbers are increasing rapidly and there is as yet no indication of saturation. Most uses of automobiles are no longer what might be called "pleasure uses." Sixty-four percent of trips to work are by car.

A premise of our discussion, therefore, should be that clear justification should always be established before there is an effort to institute measures adverse to the ownership or use of automobiles.

The motoring public is not convinced that there is a serious air pollution problem, except in a relatively few places, and then usually on relatively rare occasions.

The motoring public isn't even close to believing that the motor vehicle is a major factor in air pollution in most urban areas. It is very important that these two points be kept ever in mind.

If facts prove that a serious air pollution problem exists in a specific urban area and that motor vehicles are a substantial factor in the air pollution, as has been shown to be the case in Los Angeles, one of the greatest needs is to effectively inform the motoring public. And the motoring public, it must be remembered, is not in the main technical minded; it expects scientists, designers, and engineers to work out the technical problems and to develop any equipment or devices which may be warranted.

The blowby device for correction of most pollution from the crankcase area is a good example, with blowby devices being voluntarily built into all new American-made cars, beginning with the 1963 models—and thus, according to estimate, diminishing the most objectionable part of the automobile air pollution factor (that is, hydrocarbons) by some 25 percent. Here is a case in which a problem was dealt with by technical people. They came up with a relatively inexpensive solution and the motoring public is accepting what has been done without question. The automotive industry deserves commendation on this matter.

The motoring public looks also to the technical experts to develop sound answers to motor vehicle exhaust products, which the California Motor Vehicle Pollution Control Board states produce about 65 percent of total hydrocarbon emissions from motor vehicles (hydrocarbons being the most detrimental motor vehicle pollutant factor in photo- of cars in Los Angeles gave off 60 percent less hydrocarbons and carbon monoxide than the average Los Angeles car. Is a special device necessary in California? Elsewhere? If so, can the cost be kept down to a reasonable amount? Can a suitable length of effective service life be achieved? Can a suitable device be fitted to the millions of used cars at reasonable cost?

The motoring public will expect technical experts to answer, soundly and wisely, these and other pertinent questions—and to present answers to the motoring public in a simple, clear way so that it can, in turn, make sound judgments in developing public opinion.

It is understood that exhaust control devices, of the types being studied and tested in California, will be quite costly. The motoring public is entitled to every reasonable protection against unnecessary or excessive cost. It is interesting to note that the California Legislature adopted a law which specifically directed the California Motor Vehicle Pollution Control Board, in determining criteria for any pollution control device, to "take into consideration the cost of the device and its installation, its desirability, the ease and facility of determining whether the device, when installed on a motor vehicle, is properly functioning . . . ."

Also, the 1961 California Legislature adopted Assembly Concurrent Resolution No. 74, which directed that the board—

continue to protect the interest of the motoring public through the establishment of sound, technically reliable, and justifiable criteria; and . . . take into consideration in its certification of devices, the time schedule for compliance as defined in state legislation and its relationship to the availability of devices, the production schedules of the automobile industry, the adequacy of methods of distribution of certified devices and any other marketing factors which affect the pricing of devices in order to protect the economic interests of California's motoring public.

Let's come back to the very important question of properly informing the motoring public. If it has been proved in a city or State that a serious air pollution problem exists involving the motor vehicle, the motoring public will want answers to questions such as these:

(1) What is a reasonable "maximum acceptable" degree of air pollution?

(2) What do studies show the figures to be for the ambient air of the city in question?

(4) What proportion of the air pollution can properly be attributed to the motor vehicle?

(5) What kind of corrective measures are being sought?

(6) What will these cost the motorist?

(7) Is there demonstrated evidence that the correctives will produce the desired results and do so for a considerable period of time?

(8) Has a sensible corrective program been worked out, and if so, what is it, including full consideration of the huge numbers of used cars on the streets?

(9) Is the application of the corrective measure going to introduce new problems, and if so, what?

(10) How much of the desired corrections could be achieved by, for example, a high quality of maintenance of the powerplant of the car?

Clearly, there is a major job of informing the public—and it is a job which will take a considerable amount of time and involve the efforts of many kinds of specialists. When they are clearly understood, the American public generally responds sensibly on matters which are appropriate for public decision or individual action. The motoring public is no exception. Over the years, the motoring public has shown time and again a willingness to face up to problems which involved the use of the car—and to accept added costs and added regulation where the need has been clearly established and "sold" to the people.

Yes, the people who drive motor vehicles will face up to problems which have been clearly proved to involve them, and they will respond sensibly and constructively.

But the motoring public will react vigorously against efforts to impose hardships, added costs, or regulations upon them which they believe are not warranted. They don't like to be misled. They don't like to see overemphasis placed on problems. They don't like to see emotions determine decisions which are adverse to their reasonable interest in the use of their automobiles.

This point should be given very strong emphasis, because there have appeared from time to time proposals for actions relating to air pollution which have not been supported by adequate facts. I think

of air pollution.

In contrast, the motoring public has the right to expect that a sound and orderly procedure will be followed regarding the relationship of the use of motor vehicles to air pollution in a given community. Such an orderly procedure certainly involves, at the outset, a factual determination as to the motor vehicle air pollution factor in the given community. Yet all too few communities, where there is much discussion about what should be done about air pollution, have made thorough studies of this type.

Louisville, Ky., made such a study and, incidentally, found out that the motor vehicle was well down the list as a causative factor in its air pollution. Further to emphasize the importance of this point, the California Motor Vehicle Air Pollution Board Chairman (until very recently), in a report which he kindly sent me, made the point that it is estimated, *after much other corrective work had been done as to other air pollutants,* that motor vehicles in Los Angeles County are responsible for some 80 percent of the remaining photochemical air pollution there. In sharp contrast, the motor vehicle factor in the San Francisco Bay area is said to be 30 percent.

If, as in Los Angeles, surveys of ambient air prove that there is a serious motor vehicle air pollution problem, major correction *requires* that a high percentage of motor vehicles in use in that community have effective correctives. To the extent that devices are necessary, a sensible, orderly program is called for. In California, the legislature decided that these steps should be followed: Carefully developed criteria should be established as the basis for acceptability and approval of control devices. Thorough tests should be made of devices for which approval is sought. One year after at least two different devices have been approved, the requirement for installation of such devices will become effective. Then, the requirement will apply only to new cars. One year after the effective date, it will apply to all used motor vehicles on transfer of ownership. Two years after the effective date, the requirement will apply to used commercial vehicles. Three years after the effective date, the requirement will apply to all motor vehicles. An exception is that the requirement as to used motor vehicles will not apply to counties which exempt themselves

until there are adequate assurances that the entire program can and will be carried out. Especially as to used cars, this may involve serious problems.

The motoring public is entitled to understand such a program in advance so that if the people take exception, their viewpoints and objections may be properly considered.

The motoring public wants to know that it is being given the whole truth through sound, impartial facts and sensible interpretations. Without intent to give a wrong impression, I am afraid that that is sometimes not being done. As an example, consider this statement from a source which I am sure is intended always to be reliable: "Photochemical air pollution now occurs in 19 States and the District of Columbia." While it doesn't so state, I believe the average reader would assume that such air pollution is serious. I've lived in the District of Columbia 30 years, and I do not recall any eye-smarting smog, nor am I aware of evidence of serious air pollution. Question: Wouldn't it be wise in a statement such as that quoted to include some measure of degree of seriousness?

As part of the protection of its proper interests, the motoring public would want to know that careful studies have proved what, in each area, are the objectionable pollutants, in what concentrations they are present (compared to established standards), where they come from, and what the most reasonable remedial measures are. Getting such information necessitates adequate studies and measurements of the ambient air of the community. And involved in doing this is having suitable scientific instruments for such studies. As to determining the part which motor vehicle pollutants have in the picture, again effective instruments are essential. As further evidence that in most respects this problem is in the research phase, I quote from a 1961 California statement:

> The refinement and improvement of instrumentation as well as the development of new analytical tools are also necessary. For example, the State standards call for the measurement of hydrocarbons by a "hexane-sensitized nondispersive infrared analyzer or by an equivalent method." This analyzer is not capable of distinguishing among a variety of reactive and unreactive hydrocarbons and cannot measure some hydrocarbons known by other methods to be present in exhaust. Measurement by flame ionization, which provides a means of measuring [...]tion. It is important that new tools be developed to meet this and similar problems in the field of motor vehicle air pollution.

This urging of improvements in instrumentation is most commendable. The point I wish to make is that the motoring public has a right to expect that before any requirements are imposed regarding devices, all such practical problems of instrumentation and their adequacy will have been solved.

Los Angeles a Very Special Case

It should be constantly borne in mind that the Los Angeles photochemical air pollution situation is a very special case. As has been stated earlier, in order for serious conditions of the Los Angeles smog type to develop, a number of conditions must exist simultaneously, and they must continue for an appreciable period of time. Some other places may have the same four elements which are involved in the Los Angeles situation, but there will be very few indeed which will have these in intensities which are serious and in which the conditions will continue for the period of time necessary to cause the Los Angeles type of trouble.

Therefore, and this deserves very strong emphasis, the solutions which are developed for the Los Angeles situation should not be considered as clear guides for solving air pollution problems elsewhere. In this connection, a fact about which I think the motoring public should be informed is that the dangerous pollutants which are the principal problems in the Los Angeles situation, including hydrocarbons and carbon monoxide, are invisible and odorless. Therefore, one never sees evidence of Los Angeles smog. The haze which one sees there at times is not dangerous photochemical smog, but involves other factors.

In preparation for this paper, I encountered a statement from a reputable source in California, indicating that 10 motor vehicle exhaust control devices are now being considered. Four device manufacturers have shown that their systems will survive the Board's (Motor Vehicle Air Pollution Control Board) 12,000-mile service requirement, and "the procedure developed by the Board and the laboratories available for testing are designed to make it possible to certify two or more exhaust control systems, such that this equipment may be-

Havenner, general manager of the Automobile Club of Southern California, who was recently made a member of the California Motor Vehicle Air Pollution Control Board and who has long been working on the air pollution problem there. In fact, the Automobile Club of Southern California is cooperating with public health authorities in an important study of constituent elements in the exhausts of cars in use in Los Angeles, and has been doing so for several years.

Based on present information, Mr. Havenner's judgment is that the 1964 date is considerably too optimistic. He considers 1967 a realistic date, with 1966 a possibility. He is referring to factory installations on new-model cars. Mr. Havenner states that a "tack-on" device is not practical at the present stage of development.

Mr. Havenner gave me some further comments with which I thoroughly concur and which I think are important to bring out. He indicated that inquiries from all over our country, and indeed from many countries throughout the world, are coming in to them. They all want to know about the motor vehicle pollutant situation and devices relating thereto. The impression is created that many inquirers have in mind the forced adoption of requirements as to equipment on motor vehicles. Yet, almost none of them gave any indication that they have studied or measured the atmosphere over their home community, and if this is the case, they simply do not know their own problem, including its intensity. Many give the impression of being ready to attack the motor vehicle as the bête noir.

Recommendations for Sound Procedure

If a community or a State believes that it has a serious air pollution problem or that one is imminent and developing, the motoring public would favor, I believe, the following as a sensible, orderly, practical course of action:

1. Get the State legislature to authorize the creation of air pollution control districts.

2. Get the State legislature to establish standards for ambient air in cities and metropolitan areas.

3. Conduct thorough programs of measuring or analyzing the atmosphere in urban areas as to pollutants, including kinds of pollutants, which occur in objectionable quantities in the ambient air.

5. Develop and institute the most reasonable, effective methods of correcting the situation as to objectionable pollutants at their sources on a sensible priority basis. If the motor vehicle is found to be such a source, of course include appropriate correctives applying thereto.

6. Early in the program, initiate and thereafter continue an effective program of public information concerning the problem and appropriate remedies.

7. In the meantime, give strong support to warranted national programs of air pollution research, giving very thorough consideration to the report "National Goals in Air Pollution Research" referred to earlier.

8. In the meantime, take advantage of the very substantial gains which can be achieved through simple measures such as prohibiting use of home incinerators and improving the maintenance of engines and related systems in motor vehicles. Bear in mind the indication from a substantial study in Los Angeles of a 60 percent reduction in hydrocarbons and carbon monoxide from automobile exhausts.

As to point No. 6 on effectively informing the public, including the motoring public, the program should include the following:

1. Provide adequate, understandable facts concerning the overall air pollution problem.

2. Widely disseminate such information. Include information to motorists as to the part of the local problem which involves the motor vehicle, as to why and how they should assist in its alleviation (including guidance on maintenance practices which will greatly reduce pollutants from motor vehicle exhausts as well as reduce gasoline consumption), explanations of the "blowby" device and the importance of effective maintenance thereof, and explanations of such other measures as apply particularly to the motoring public.

3. Justify to motorists any anti-air-pollution devices which are on or should be put on their cars. Such justification should deal strongly with costs of devices, installation, and mainte-

nance. It should also be made clear that any such device has been proved reliable and easy to check and maintain, and that it will not seriously affect the efficiency or safety of motor vehicle operation.

4. Give special attention to what are considered to be appropriate financial and other responsibilities of motorists as to air pollution control, with carefully considered reasoning as to their justification and equitableness.

CONCLUSION

The motoring public is not aware of any widespread air pollution problem. Where comprehensive community ambient air studies show that there is a serious air pollution problem, the motoring public—a very large proportion of the total public—will be interested when properly informed. If motor vehicles are proved to be important in the problem, the motoring public will respond sensibly and constructively provided reasonable and justifiable corrective measures are developed, a sound priority program is followed, and the motoring public is brought into the picture and kept adequately informed.

Resolution on Air Pollution Adopted in 1961 by the American Automobile Association

AAA calls for stepped-up research of urban air pollution and of the most practical and economical means of prevention or correction where sound analyses and studies prove that the problem is serious, and identify and measure causative factors.

As to air pollutants from motor vehicle use, AAA urges continuing active study and development to the end that effective corrective devices be developed at minimum cost to motor vehicle owners.

AAA urges political subdivisions to exercise caution before enacting legislation making compulsory the installation on motor vehicles of anti-air pollution devices. Surveys should first clearly prove that pollutants from motor vehicle use are serious enough to warrant such legislation; because of motor car mobility, regulations to be effective must apply to a wide area; effectiveness and continuing dependability of reasonably economical devices must have been proved; suitable devices for testing results must be available; reasonable advance notice must be given; suitable administrative and enforcement measures must be planned; public acceptance must be assured.

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DISCUSSION

E. K. von Brand. This is in regard to the instrumentation needed to take all the corrective steps indicated by previous speakers. One type of instrument is called a tape-recording smokemeter or exhaust pattern recorder, and it can help to clear the air when used for optimizing the adjustment of fuel-burning equipment, particularly the automotive engine. The American Petroleum Institute and the Society of Automotive Engineers have investigated this equipment for a good many years now. And many people are taking advantage of it, especially abroad. Even in Japan, they have tried it. This gas sampler is operated as a rule with fully continuous tape motion, but can also be set up as sequential sampler with repeat cycle timer. While widely used for diesel work, it is even more helpful for checking the adjustment of gasoline engines. Exhaust records made with this recorder show that most gasoline engines are poorly adjusted, smokewise and emissionwise. This fact is not known to operators or servicemen because the exhaust looks clear to the unaided eye. This is true for old engines and very much so for new engines, too, as I know from personal experience. In the stop-and-go driving in urban areas, where engines idle a good deal of the time, better adjustment is very helpful in reducing air pollution. Adjusted for clean-as-possible within the limits of design, no matter how poor the equipment, an engine can still be made to perform up to its best ability. Better combustion will sustain good engine performance, and reduce maintenance costs; deposit formation is retarded; oil stays cleaner longer; spark life is longer, and that means satisfactory spark life. In case the engine is in poor condition in some respects, a continuous exhaust record from this recorder in connection with other instruments, and very often by itself, provides a means of diagnosis of ring wear, oil pumping, and oil choke; it's not a mere smokemeter; it's an exhaust pattern recorder. Because of overrich mixture from excess fuel supply, automatic chokes are particularly bad. In a high percentage of tests it has been found, with a tape speed of 4 inches per minute, that the exhaust clears up in 2 or 3 minutes, as it should; then all of a sudden, after another minute or two, a very dirty, gray smoke is produced. However, the exhaust *looks* clear. Nobody knows. Air pollution goes on. Nonparticulate emissions are also important. Studies by numerous authorities show that the gasoline engine, rather than the diesel, is the main producer of toxic gases. The development of sensitized tape might increase the possibilities of this recorder. However, just as it is, it can be used even for nonparticulate matter, provided a useful correlation is established between the presence of the toxic gas and particulate emissions—foreign particles, fumes, oil, etc. This possibility should be more fully explored by investigators with the proper facilities.

Christopher R. Landmann. In another session, Dr. Wynder of the Sloan-Kettering Institute mentioned medical effects on mice in studies seeking to differentiate the various pollutants. He found emissions of diesel engines less toxic and less cancer-producing than emissions of gasoline engines. I would like Professor Meyer to comment, particularly on quantitative differences in the effects of emissions from diesel and gasoline engines.

Meyer. I don't think I'm qualified to discuss the problem of cancer-producing characteristics of various constituents of exhausts from either gasoline or diesel engines. In my opinion, these matters are largely yet to be explored. We are not certain whether smears on the skin of mice relate properly to the lung cancer incidence. So it is a little early to speculate on whether the diesel engine or the gasoline engine is the more serious offender. I do know that in Europe the concern has been primarily with the diesel engine. In this country we have been looking more at the gasoline engines simply because we have so many more of them. But I believe it is too early to make numerical comparisons.

G. C. Hass. In Dr. Chambers' paper, he includes an estimate that the current California hydrocarbon standard may accomplish only a 40-percent reduction of total emissions if applied to all vehicles. I believe the present test procedure adopted by the Motor Vehicle Board does take into account the warmup factor which Dr. Chambers feared would reduce the overall effect of control. Also, two recent surveys of the present level of motor vehicle emission would also serve to support the slightly more optimistic contention that the total reduction would be on the order of 60 percent to 70 percent rather than 40 percent.

Chambers. I will accept the correction as to those specific small percentage differences. I suspect that all of us recognize that any of these guesses are merely best guesses at this stage. However, I don't think this change detracts from the general thesis. If you increase the percentage by 10, it

trying to convey.

W. J. O'Connell (for San Francisco Bay Area Air Pollution Control District). The Federal Government, as a major purchaser of diesels and as a governing authority for interstate trucks and buses, should: (1) carry out or pay for engineering developments to control odorous emissions that cause localized annoyances almost everywhere in the United States; (2) require Interstate Commerce Commission (ICC) vehicles to install odor control equipment; (3) require ICC vehicles to maintain smoke-control procedures; (4) procure Government vehicles only with odor control equipment; (5) require Federal vehicles to conform to smoke-control procedures.

Richard A. Wolff. Mr. Chandler mentioned that it's time, after 10 years of effort on the part of the Automobile Manufacturers Association, to perfect something in the way of a crankcase device or blowby device. And he also mentioned that the devices will be installed—voluntarily, as we all know—on all 1963 cars. About 3 years ago and again about 2 years ago, a very impressive group came into our Department of Air Pollution Control in New York City and vehemently pointed out that the crankcase device, although very fine in California or parts of California, was not necessary at all in New York City or in other cities aside from Los Angeles County. I should like to know whether or not Mr. Chandler, speaking for his committee, feels now that New York City will benefit in its fight against air pollution through the installation of crankcase devices.

Chandler. The best way I can answer that question is to read the appropriate statement in my paper. "Performance was deemed sufficiently satisfactory, however, so that when the U.S. Department of Health, Education, and Welfare stated that installation of blowby devices on a nationwide basis would be beneficial, industry was ready to announce that the 1963 vehicles would be so equipped." I don't believe that the industry is totally competent to judge the effects within the various communities. That is why we have suggested that each community define its own problems, with the help, of course, of the Public Health Service.

Wolff. I won't prolong this. I think there is a difference between the Automobile Manufacturers

cause they feel it is a worthwhile endeavor.

Chandler. Your point is well taken. I think one of the reasons that made it easy for us to make this decision is that the reduction was as significant as it was. We're talking in terms of a 40-percent reduction of hydrocarbons at a relatively small expense. I think it's worth the gamble to install these devices in order to achieve these reductions as soon as possible. Obviously, research must be done to determine the need nationwide and, of course, that work is now being done.

Genaro G. Costantino. Mr. Chandler, in view of the established fact that the vapors extracted from the crankcase to be recycled back to the combustion chamber contain harmful ingredients such as metallic fuzz, carbon, varnish, acid, etc., why aren't effective prefilters used on blowby devices to remove the impurities? Is it not reasonable to assume that if these impurities reach the engine, engine wear may be accelerated, causing a drop in engine efficiency and thus resulting in increased blowby? On this assumption, will crankcase blowby devices do more harm than good unless prefilters are used? Also, will lack of proper maintenance of the blowby devices result in poor engine performance, thereby also increasing the crankcase blowby?

Chandler. In answer to your first question, if you will examine the engines being built today which contain blowby devices, I think you will find prefilters. Some of them are not readily visible. They are buried inside the engine with the oil separators. Every effort is made to clean the vapors before putting them back in the engine. Several systems, for example, put some of the vapors into the dirty side of the air cleaner. So I would say that the engines which contain these devices have taken note of the fact that the vapor should be cleaned as much as possible. This, to me, seems to revoke your second question on excessive wear. Obviously, we endeavor to build engines that do not have excessive wear. I think our recent warranties of 24 months, or 24,000 miles, prove that statement, and when a car reaches 100,000 miles, we'd like to sell the customer another one. So that gives us a pretty strong incentive to make sure that our engines do not wear out prematurely. Your third question was: Will lack of proper maintenance result in poor engine performance and thereby increase blowby?

If a ventilation valve is used and it becomes stuck, I think the biggest problem is that you may have backflow through the filler pipe; then you will detect odor and be unhappy and maybe have the valve cleaned. Basically, I don't think there will be any noticeable letdown in engine performance, but this is a tough question. The answer again depends upon engine condition, mileage, and a variety of factors.

Robert I. Sewall. Mr. Maga, don't you think there is a direct relationship between the amount of air pollution and the extent to which a city's population drives to work or takes advantage of public transportation, especially public transportation which does not use internal combustion engine power? Also, don't you think this represents another avenue of approach to the problem of air pollution?

Maga. Certainly. The extent of the motor-vehicle-created air pollution problem is related to the number of vehicles and to the amount of fuel burned. Any steps taken to reduce the total number of vehicles used in metropolitan areas would have the effect of also reducing atmospheric concentrations of pollutants from motor vehicles. While we cannot look to mass transportation as the sole answer to the problem, it will be of benefit by decreasing vehicle use in areas with air pollution problems. It would be incorrect, however, to conclude that mass transit systems will do away with the need for the control of motor vehicle crankcase and rear exhaust emissions.

JOHN D. CAPLAN
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First, I'd like to mention briefly a thought of Dr. Chambers' that I think we should consider. In our ignorance, we must be careful, to use a phrase he likes, not to do violence by selective control of ingredients. When we don't understand the process involved in our air pollution problem, we may through ignorance and selective control actually make things worse. This is one of the messages I've gotten from Dr. Chambers' comments. I think it's important because, for instance, nontechnical people get frustrated and impatient—as Senator Williams seemed to do yesterday—with this constant demand for research and more research. This is understandable. Yet, as a responsible public official, I'm certain he would agree that such research is vital if we're going to make the correct decisions. And therefore, I think it behooves such officials to depend upon competent and impartial experts such as Dr. Chambers for guidance in these matters. Mr. Marsh also indicates that the public too, who sometimes get impatient with the never-ending research, will accept reasonable solutions to the motor vehicle problem if this is explained to them and they are not required to make a selection between scientific opinions from conflicting sources. In other words, the citizen doesn't want to be a party to the old shell game of paying his money and taking his chance that his investment may do some good. He wants some reasonable assurance of success.

With respect to the effect of motor vehicles on health and property, Dr. Nelson certainly was given a most difficult assignment. The fact that he had to resort to a discussion of effects of air pollutants in general is actually a reflection of the fact that we're still not in a position to give definite statements to the motoring public that, if we do this to vehicles or we do that to vehicles, this will occur or that will occur. And to quote Dr. Nelson, "We still can't allocate observed effects to sources of specific origin."

Mr. Chandler talked about the future of powerplants and everybody has thoughts along this line. It amuses me to observe that when we're talking about a field other than our own, it is easy to make suggestions as to what should be done. For instance, the gentleman from Providence (Mr. Costantino) today indicated what should be done in designing blowby devices. The point I want to make is that alternative sources of power have been and will be evaluated and were a matter of concern long before the motor vehicle industry became aware of the air pollution aspect. In other words, for the last 50 years this has been one of our constant endeavors. So it isn't untrodden soil and virgin territory when we said that we will have these unique developments in time. My reason for emphasizing this is to point out that although we shouldn't base our immediate hopes on this, it does promise a long-term solution.

When reading Congressman Schenck's remarks, I was confused on one point. For instance, he emphasized that those who design motor vehicles are in the best position to deal with the problem of vehicle emissions, and yet he also stated that the Federal Government should work in the field of establishing a better relationship between design and emissions. Now these two statements could be construed as being mutually contradictory. But perhaps this is just a reflection of environmental effect from the city we're in or, to phrase it another way, anything you can do, we can do better. Finally,

I was impressed with the remarks that Mr. Bright made on the problems of enforcement in administering vehicle control. It occurred to me, in view of the complex problems and the manpower and time involved, that perhaps in a few years the cost of the control devices themselves is not going to be so important. It may be a case of the tail wagging the dog, and the administrative and enforcement costs may be the principal burden that the motorist has to bear. When we consider implementing programs, we should look not only at direct costs of a device but also at the administrative costs and the enforcement costs, because such costs are just as real in dollars as are any of the other costs. I seemed to sense a general agreement among a number of the authors and discussants on this matter of philosophy. In other words, Mr. Marsh, Mr. Maga, Mr. Chandler, and Mr. Bright have been in rapport on what constitutes a sensible and logical approach for a community to follow in establishing motor vehicle control. Mr. Maga was quite modest when he said that his was an approach you could consider. I think he was overly modest. And I think all the groups in California responsible for setting up this program certainly have given considerable thought to what is a reasonable and sensible solution. However, we must remember that although we may agree on the techniques and the operations through which we establish a program or the necessity for a program, the procedure is not worth a thing unless the facts and the data we feed into it are correct. Otherwise, we arrive at the wrong goal and, as an example, I call your attention to Mr. Hass' comments and Dr. Chambers' reply; even in the matter of factual information, evidently we're not all in complete agreement.

Similarly, Mr. Marsh's pleas for informing the public lead me to issue a warning; it is important not only that we inform the public but also that we inform the public correctly. In the long run I have confidence that the American public will eventually reach the right conclusion, and you'd better be sure you're giving the public the correct information! Finally, I'd like to summarize the discussions and I think this can be done in one sentence. There seemed to be little questioning of the philosophy, such as whether to control or not to control, or how to determine what is necessary; the main differences of opinion seemed to be based on a lack of agreement on the facts. So, in this respect, things haven't changed too greatly since the 1948 conference.

Supplementary Statement Submitted for the Record

THE HAZARDS OF DIESEL AND AUTOMOTIVE EXHAUSTS TO THE EXTREMELY SUSCEPTIBLE PERSON

Marseille Spetz, M.D.
Arcata, Calif.

(A preliminary account of this case was submitted at the conference. This is an extended discussion of the same case.)

Consideration of the health hazard of motor fumes is generally oriented to the average person. There are, however, some people who are unusually susceptible to chemical air pollutants from several sources. A large dose of exhaust fumes in these patients can prove fatal. This is especially true if the patient has taken care to avoid incitant chemicals, so that an exposure finds the patient in an unusually susceptible state. A small amount of chronic exposure to fumes will keep a person in some degree of adaptation, so that moderate increases in dosage are not reflected in a sharp reactive response. People in a stage of adaptation to small doses of chemical air pollutants may be chronically ill without being aware of the incitants of the illness.

An example of a response in an acutely susceptible patient was furnished me on the way to this meeting. I traveled to this conference with another doctor and his wife. This woman is particularly susceptible to all chemical air pollutants. On our trip here Sunday, 6 hours of exposure to the fumes of moderate truck travel on the Pennsylvania Turnpike brought on an acute reaction consisting of a state of temporary paralysis of one side, with a Parkinsonian-like tremor, severe migraine headache, and finally, stupor. Fortunately, with administration of alkali by mouth, and oxygen inhalation, she was recovered by the next morning.

Patients can be protected to some extent from motor exhaust fumes by breathing through an activated carbon filter. However, this precaution was not adequate to protect this patient from this particular exposure, even though she breathed through it continually during the period of maximum air pollution.

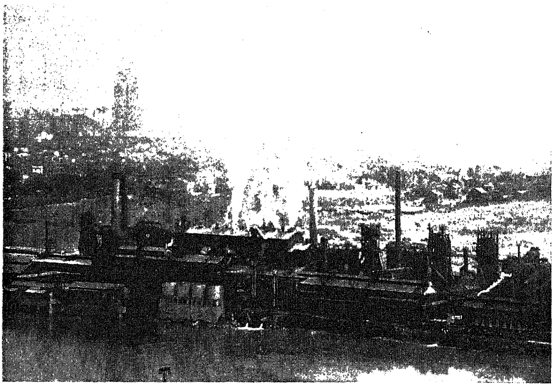
This reaction to motor exhausts is, in effect, an acute allergic reaction. The predominant cellular abnormality seems to be a cellular acidosis. Prompt administration of alkali by mouth and oxygen in-

health from the chemical environment can be found in Randolph, T. G.: "Human Ecology and Suscep-

N.Y. December–January, v. 17, 1962–63 issue, p. 6.)

Panel B

THE INDUSTRIAL PLANT, THE POWER-PLANT, AND THE MUNICIPALITY



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AIR POLLUTION FROM INDUSTRIAL OPERATIONS AND ITS CONTROL

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According to the 1958 Census of Manufactures, there are nearly 300,000 manufacturing establishments in the United States. No two of them are exactly alike in their emissions of air pollutants. Those with the greatest pollutant potential may be classified into five groups: the dusty industries, the smoky industries, those which emit odors, those emitting irritating or toxic substances, and for lack of a better term, those which emit photochemical pollutants. Obviously, some industrial units fall into more than one class.

Dusty industries.—The major dusty industries and the specific operations producing dust are shown in table 1. One can readily see that wherever a solid is broken down into fine particles (by blasting, crushing, grinding, pulverizing, or sanding) or wherever the fine particles are subsequently handled (conveying, classifying, mixing, drying, or calcining), dust problems may arise.

The various dusts emitted differ one from another in chemical composition, density, particle size range, and obviously in the amounts emitted. Generally dusts vary in size from less than 0.1 micron [1] (carbon black) to 1,000 microns (sawdust). (See table 2.) The smaller particles, particularly those from 0.3 to 1 micron, tend to remain in the atmosphere and restrict visibility. Particles greater than 40 microns tend to fall rapidly to the ground fairly close to the source; those between 10 and 40 microns tend to fall somewhat farther away. The intermediate sizes are variable in their actions. But, generally, primary problems resulting from dust emissions are the dustfall nuisance from the larger particles and the visibility restriction from the smaller ones.

One may also consider metallurgical fumes as dusts, although they are extremely fine particles formed by the condensation of metallic vapors. These fine particles act like fine dusts and, unless they are toxic, their chief effect is visibility reduction.

Smoke.—The combustion of fuels is the common denominator of all industry. Manufacturing operations require heat or power, and usually both, and both (except in the case of water power) arise from the burning of fuels. Smoke and its control will be discussed by speakers to follow me, so it is sufficient here just to say, again in generalities, that most smoke arises from the inefficient burning of bituminous coal and waste wood. Another all too common source of industrial smoke is trash burning, either for waste disposal or for salvage operations. The chief effect of black smoke is the soiling or blackening of surfaces. Emission of dense smoke is unnecessary and inexcusable in this day and age, but others will tell you more of this.

Odors.—Probably the most annoying and difficult of all air pollution problems is the odor problem, and industry emits its share. A list of odor-producing industrial operations is shown in table 3. Most of the odors arise from the evaporation and subsequent loss of simple organic liquids from chemical operations, e.g., hydrocarbons, alcohols, aldehydes, amines, and mercaptans; from handling and use of solvents; or from the putrefaction of animal or vegetable matter. Fermentation operations (e.g., bread baking) also produce noticeable odors. Highly odorous hydrogen sulfide may be emitted wherever sulfur compounds are handled.

The big difficulty with odors is the fact that one can measure them only by the nose, and noses are notoriously variable and undependable. Further,

[1] A micron is 1/25,000 inch.

will drive blocks out of his way to sniff the aroma from a neighborhood bakery, but someone who lives next door to the bakery may complain that the intense odor interferes with his sleep.

More often than not, odors are the spark to neighborhood complaints of air pollution. I am convinced that the real problem of petroleum refineries, for instance, is not hydrocarbons or smoke, but the typical odor noticeable in and near the refinery.

The chief effect of industrial odors is the esthetic offense against the sense of smell, and to many this is a distinct nuisance. Occasionally a strong odor can produce nausea, but this effect is very unusual.

Irritating and toxic substances.—The most common irritating or potentially toxic gas emitted industrially is sulfur dioxide, but here again chiefly in flue gases from the burning of coal and oil.

A few industries use sulfur dioxide in their processing operations and lose some in the process. The major industries of this type are nonferrous smelting, the manufacture of wood pulp, some chemical operations, particularly sulfuric acid manufacture, and the wet milling of corn. In high concentrations, sulfur dioxide affects those with respiratory diseases; at lower concentrations it is irritating to the nose and throat. However, the more common air pollution effects of sulfur dioxide, in the concentration range most likely to be encountered, are marking of vegetation (high concentrations kill some plants) and corrosion of metal and stone structures.

Another potentially toxic industrial pollutant is a group of fluorides, both in gaseous (hydrofluoric acid) and particulate form (sodium and calcium fluorides). Chief emitters of fluorides, in those cases where fluoride-containing dusts are handled, are the steel industry (sintering and open-hearth operations), aluminum manufacture (electrolytic cell), superphosphate manufacture, and various ceramic industries, particularly brick and tile manufacture.

Fluoride dusts settling on forage may be ingested by cattle with subsequent damage to the animals. Certain flowers, e.g., gladioli, are sensitive to fluorides, and some citrus growers suspect fluorides affect yield of fruit.

Occasionally acid and alkali mists are discharged from general industrial operations with consequent amounts emitted in vehicular exhaust.

Photochemical pollutants.—Photochemical smog, of the type commonly encountered in Los Angeles and on the west coast, and less frequently elsewhere, results from a photosensitized atmospheric reaction between reactive hydrocarbons (chiefly olefins), perhaps certain organic solvents, and oxides of nitrogen. The chief source of olefinic hydrocarbons and nitrogen oxides is motor vehicle exhaust, but some of each are also emitted industrially. All burning operations produce nitric oxide. Hydrocarbons are emitted in the manufacture, transportation, and marketing of gasoline. Solvent losses occur in a variety of operations, principally in painting and application of other protective coatings.

There has been a tendency in some quarters, in my opinion, to overestimate the role of solvents, the more stable hydrocarbons (particularly paraffins and aromatics), and flue gases containing low concentrations of nitrogen oxides, in the production of photochemical smog. Certainly this type of smog is a genuine nuisance, but it comes almost entirely from motor vehicle exhaust.

Control methods.—A variety of control methods are utilized by industry to reduce emissions to the point where air quality is acceptable. Occasionally an air pollution problem can be cured by changing fuels (e.g., natural gas to replace coal) or by shifting raw materials (use of granular material instead of a fine dust), but such changes are seldom economically feasible. In a few areas, plants are so located with respect to people, plants, and animals that no diminution of emissions is necessary, but this situation is rare. Occasionally, the value of material recovered will pay for collection equipment.

In the vast majority of cases, control equipment must be installed solely to prevent or greatly reduce emissions to the atmosphere. Control equipment requires a capital investment and involves extra operating costs over and above an uncontrolled process. Thus an economic consideration comes into the picture. For an equitable solution the cost of control must be weighed against the frequency, severity, and nature of the effect caused by the pollutant. Most of the "hassles" between government and industry, or between the public and both government and industry, are incurred by differences of opinion in weighing the equities involved.

is an economic one, inasmuch as the effects of pollutants are usually of an economic or nuisance nature.

Fortunately, equipment of various costs and efficiencies is available for control of most pollutants. In the dusty industries, dust particles may be removed from the air stream by gravity or centrifugal force (settling chambers, cyclone collectors); by impingement (cloth filters, water scrubbers); or by electrical forces (electrostatic precipitators). If the dust-bearing gas can be contained, one of these methods will remove the dust, but at a cost which consists not only of capital cost but also operating and maintenance costs.

Smoke control, unlike dust control, involves prevention of pollutant formation by following good combustion practice in properly designed equipment. Both good practice and good equipment are necessary. One can't eliminate smoke by even the best practice in inadequate equipment. Conversely, the best equipment releases smoke if operated in a slipshod manner.

Open burning of industrial trash, on the other hand, produces smoke no matter what is burned or how it is burned, whether it is paper boxes or culm piles. Usually there is little excuse for open burning in industry.

The control of odors presents an entirely different problem from the control of smoke and dust. If the odorous gas comes from a point source, it can usually be contained and destroyed. For example, odors from varnish kettles, rendering kettles, or wire enameling ovens, or the tail gases from a phthalic anhydride plant, may be contained in a duct and incinerated either by direct flame or by catalytic combustion. If the material is valuable, it may be recovered by adsorption on porous solids.

When the odorous material is emitted from many sources, such as leaky valves, or multiple transfer operations, or from wide areas such as catch basins, open chutes and bins, or waste lagoons, the problem is considerably more difficult. Good housekeeping will go a long way toward abating odor; sometimes odor counteractants are effective. But the completely odorless plant, particularly in the organic chemical industry, the food industry, and the petroleum industry, is still in the future. On the other hand, with good design, and constant attention to good housekeeping, a buffer zone of only a few

Emissions of toxic and irritating gases present a different problem from the emissions discussed so far, which at most cause economic damage or nuisance. Fortunately, the most common pollutants, sulfur dioxide, fluorides (gas or dust), and carbon monoxide are easily kept below the threshold level for human discomfort. The control problem again becomes an economic one.

At moderate concentrations, sulfur dioxide may be utilized chemically or recovered by water scrubbing at not too great a cost. Economic burden arises when one tries to remove the low concentrations in hot flue gases. Scrubbing with water or ammonia solutions can be made to work but at an intolerable price. Fortunately, in most cases the diluting power of the atmosphere is sufficient to prevent damage even to sensitive vegetation except under infrequent meteorological conditions.

Practice with regard to fluorides is highly variable. In one plant, addition of lime to a fluoride stream converts the gaseous acid to calcium fluoride, which is in turn removed in electrostatic precipitators. Whether this degree of removal is necessary or not is the subject of several current projects.

Carbon monoxide in high concentrations may be burned and heat recovered, as is practiced in some refineries and in steel mills. At the low concentrations from most industrial operations, abatement is unnecessary.

Acid and caustic mists can readily be removed from effluent gas streams by several types of mist eliminators (fiber filters) so there is little excuse for this type of emission.

The problem of abating the so-called organic precursors of photochemical smog, i.e., hydrocarbons and solvents, is one confused by politics and poor analytical methods. There is little data to show that organic materials other than olefinic hydrocarbons are significant participants in the photochemical smog reaction. Yet there is considerable clamor to abate all hydrocarbons and most solvents. In practice, volatile hydrocarbon emissions from refinery operations are controlled by a combination of floating roof tanks, covered separators, good housekeeping, and waste gas flaring. Several methods of reducing vapor loss during transfer methods are used in the refinery and at loading docks. The same methods could be used at filling stations. Even so, the technical and economic

as from house painting, or the gas stream concentration is low, economic recovery methods are not available.

Similarly, nitrogen oxide removal from most industrial combustion gases is presently out of the question. High concentrations such as are encountered in the tail gases from nitric acid plants or the brown plumes from nitration processes can be almost entirely abated at a reasonable cost by catalytic reduction to nitrogen and water vapor.

The economic problem.—It becomes apparent from a little study that most industrial pollution problems are susceptible to economic methods of control. Those which cannot be controlled eco-

TABLE 1.—*The major dusty industries*

Industry	*Principal dust-emitting operations* (See Key)
Carbon black	3, 4, 7, 11
Cement	1, 2, 4, 5, 7, 10, 11, 14
Chemicals (e.g., soda ash, pigments, dyes)	2, 3, 4, 5, 6, 7, 10, 11, 14
Fertilizer	1, 3, 4, 5, 6, 7, 10, 11, 13, 14
Food: Dry goods	4, 5, 6, 7, 10, 11
Foundries—ferrous and nonferrous	4, 7, 8, 9
Grain and feed	4, 5, 6, 7, 10, 11
Lumber and wood products	9
Machinery	12
Minerals:	
Lime, gypsum, asbestos, rock products, etc.	1, 2, 3, 4, 5, 6, 7, 10, 11, 13, 14
Mining	1, 4, 5, 6, 13, 14
Smelters	1, 2, 3, 4, 5, 7, 8, 13, 14
Steel	2, 3, 4, 5, 7, 8, 10, 14

Key to dust-producing operations:

1. Blasting.
2. Calcining.
3. Chemical processing.
4. Conveying.
5. Crushing and grinding.
6. Drying.
7. Loading and unloading.
8. Metal processing.
9. Milling, cutting, and forming.
10. Mixing.
11. Packaging.
12. Sanding and finishing.
13. Sorting.
14. Storage piles.

Flour	1–75
Metallurgical dust	0.5–100
Coal dust	1–100
Coal, pulverized	5–500
Foundry dusts	1–1000
Cement dust	3–100
Sulfide ore for flotation	7–200
Fertilizer	25–1000
Sawdust	50–1000

TABLE 3.—*Odorous industrial operations*

Industry	*Odorous material*
Chemical manufacture	Hydrogen sulfide, ammonia, amines, alcohols, aldehydes, phenols, mercaptans, esters, chlorine and chlorinated organics, etc.
Coke ovens	Sulfurous, ammoniacal, and phenolic compounds.
Fertilizer	Bone meal, organic nitrogen compounds, ammonia
Food and kindred products.	Dairy wastes, cannery wastes, fish, baking bread, chocolate, flavors, packinghouse wastes, meat products for rendering, coffee roaster effluents, cooking odors, etc.
Foundries	Core-oven odors, quenching oils.
General industrial	Burning rubber, forming and molding plastics, incinerator smoke, solvents and lacquers, asphalt.
Petroleum	Sulfur compounds from crude oil, cresols, asphalt.
Pharmaceuticals	Biological extracts and wastes, spent fermentation liquors.
Pulp and paper	Sulfurous compounds.
Soap and toiletries	Perfumes, animal fats.
Tanneries	Hair, flesh, hides.

nomically are generally producing levels of pollutants for which adequate justification for control is wanting.

On the other hand, a few plants always seem to have troubles, whereas others do not. The reason may lie in personalities, or the lack of an enlightened public relations policy. It may be absentee management, a deep-seated distrust of governmental controls, or just plain lack of attention to air pollution problems.

Most likely, though, the problem is related to factors difficult to change. It is common knowl-

edge that the air pollution problems of old plants are far more difficult to solve than those of new ones. Again, this is basically a question of economics. It is far simpler and cheaper to include modern control equipment in the design of a new plant than to find space in an old one for even a much smaller unit. In fact, in some old plants it is almost impossible to make any kind of equipment alteration. So a higher total cost for control is involved than there would be in a new plant. The point is that more thought must be given to the problem of old plants. Accelerated amortization allowances may be the answer. Or it may be that air pollution regulations should take age of plant into consideration. On the other hand, management has a moral obligation to design its new plants with high priority given to avoiding atmospheric pollution.

I have attempted to discuss the major pollutants emitted to the atmosphere from industrial operations, the effects of these pollutants on man and his property, the methods available for pollution control, and some of the problems which must yet be solved.

There can be no doubt that progress is being made in clearing the air of industrial waste, but we still have a long way to go. This is a challenge to industry, but one I am sure it will meet.

DUSTRIAL OPERATIONS AND ITS CONTROL

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Dr. Faith has performed his usually thorough job in summarizing the many air pollution responsibilities which have been faced, and are being faced, by industry. Through his classification of all industry under one or more of five categories—that is, producers of dust, smoke, odors, irritating and toxic substances, and photochemical pollutants—he has emphasized the similarity of problems among the various industrial groups.

Many of you who have worked in the air pollution field for some years will recognize that our ready acceptance of Dr. Faith's classification shows that personnel working in this field have made considerable progress in their understanding of air pollutants. I recall a program which I was on at the University of Michigan in 1950, when each industrial representative emphasized that his problem was different and that very little could be learned from workers in other industries. Today, thanks to many meetings of the type we are holding here, to a better understanding by each of us of our own problems, and to help we have received from suppliers of control equipment and from regulatory personnel, we now attack and solve a problem, not as a particular company problem but rather as a problem viewed in terms of the fundamentals involved.

The progress that has been made in air pollution control over the past 10 or 15 years is also demonstrated by another point in Dr. Faith's paper. As he points out, most of the problems caused by dirt and smoke emissions have been solved technically, and the focal point is now on construction of air pollution control equipment as funds become available. Construction activities, no doubt, will continue for another 10 years or so with the continued cleaning up of the community air.

The nuisances caused by odors are difficult to discuss. Much success has been achieved in solving individual problems, yet some of the remaining problems are difficult for industry to solve because odors are not amenable to quantitative examination. Very close cooperation between regulatory personnel and industry is required to arrive at solutions that satisfy the community.

It is in the fourth classification—toxic substances—that public health and industrial personnel are having a difficult time because of the unknown chronic effects of pollutants, some of which (sulfur dioxides and nitrogen oxides) are almost universally present, although in concentrations well below the limit set by the industrial hygienists for short-time exposure. Do these low concentrations have an effect after years of exposure? Here is an area where most of us believe a great deal of research is required. The results must be forthcoming as quickly as possible in order that the population may be fully protected without setting arbitrary and unnecessarily restrictive air quality standards.

The last category—photochemical pollutants—is an area where the many research projects on effects of pollutants and required control procedures are coming to fruition. It appears that the rate of progress in this area is now so rapid that in the next several years the magnitude of problems due to photochemical pollutants will diminish.

The last point I wish to make concerns the economic problem discussed by Dr. Faith. Last June the University of Michigan School of Public Health held a seminar on "Community Air Quality Standards." The discussion group to which I was assigned had as its chairman Dr. Ralph Smith of Wayne State University, and as its subject, "Eco-

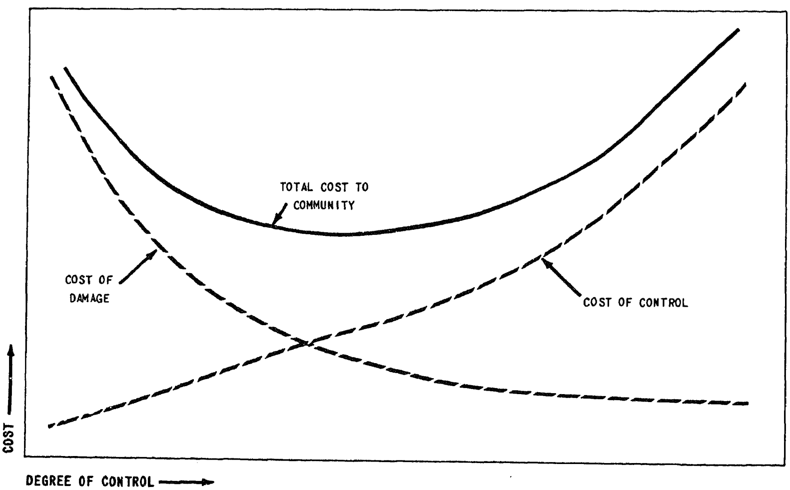
nomic Aspects of Community Air Quality Standards." Mr. Albert Pasini of Detroit Edison gave a graphical presentation of the economic concept (fig. 1). The curves relate the cost of air pollution damage and the cost of controls and the total cost to the community of air pollution.

The curve on the left, "Cost of Air Pollution Damage," is meant to include such things as soiling damage, vegetation damage, and loss of individual sense of well-being. The affected population must, of course, be studied to arrive at this cost of air pollution damage. The curve on the right, "Cost of Control," is the amount of money spent in the community in controlling emissions from factories, automobiles, backyard incinerators, etc. By adding the two curves, the total cost to the community for any desired degree of control is obtained. Thus, the economic consequence of any chosen level of control is easily seen. The chosen level should be near the optimum point of the curve. This might be thought of as the point of maximum community satisfaction. However, it is apparent that some communities will want to spend more money than can be justified on an economic basis. Other communities may be less concerned with air pollution and will be willing to settle for a point to the left of the optimum.

I believe this presentation gives a rationale for arriving at an economic balance between the two costs. It is recognized that some difficulty exists in finding information in a given community to plot the cost of damage. Progress is being made to obtain these data through community surveys. The committee concluded that a more complete and comprehensive study of the costs of air pollution is badly needed and that research efforts should be undertaken. One of the important areas here is to determine the human response to the damage and to establish judgment values for less tangible effects such as odors or nuisances. Where effect on health may be involved, it is understood that the economic evaluation should be commensurate with the severity of the effects.

Finally, I am happy that the air pollution control program in this country is moving rapidly ahead. We can all be proud to be a part of it. Dr. Faith is to be congratulated for his succinct appraisal of industry's part in this program.

ECONOMICS OF AIR POLLUTION CONTROL



AND ITS CONTROL

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At the first National Conference on Air Pollution held 4 years ago, G. V. Williamson of the Union Electric Co. made an able report on the status of thermal powerplants as they affect the atmosphere. At that time engineering progress had given the industry fairly trouble-free designs, or the information on which to base such designs, in at least three areas:

1. *Elimination of smoke,* i.e., unburned hydrocarbons from coal and oil.
2. *Flyash.*—That is, the particulate matter associated with the combustion of pulverized coal.
3. *Stack design.*—That is, the prevention of problems associated with turbulence caused by the plant or the nearby terrain, and the safe diffusion of SO_2 for the size of plants then being built.

Today, it is possible to say that there have been no adverse developments in these three problems, which were then regarded as solved. There has been continued effort to tighten the limits so far as the discharge of particulate matter is concerned. In stack design a new problem has developed, but it will be discussed later.

In 1958 two areas were listed as problems under observation, with solutions still to be developed:

(*a*) *Sulfur:*

This included the problems associated with removing a relatively large fraction of the sulfur from the coal before burning it, or the elimination of the resulting sulfur oxides from the stack gas after combustion.

(*b*) *Nitrogen oxides:*

These materials had then just been identified as possibly contributing to the air pollution problem in certain west coast situations.

While a great deal of work has been done in direct attack on each of these areas, the existing solutions are mainly means of making an oblique adjustment to the situation. The results of direct attack and the current adjustments to the two problems are:

(*a*) *Sulfur:*

The elimination of sulfur from the coal before burning continues to be a difficult technical problem, and a matter for joint research effort by the utility and coal industries. Some very useful work has been accomplished in this period, but it appears that an economically satisfactory solution is still some distance in the future.

Removal of sulfur oxides from the combustion gas also has received continuous research attention. Problems here are both of a technical nature and a matter of economics. A number of methods have been investigated, and work is continuing on the most promising one.

The method of adjusting to this problem has been to exercise a great deal more care and foresight in the selection of stack heights, giving due consideration to the expected local meteorological conditions, to the end that sulfur oxides will be fully and effectively diffused in the atmosphere, and thus never become a problem at ground level.

(*b*) *Nitrogen oxides:*

Further development in the study of the oxides of nitrogen seem to indicate that, under most normal conditions, and in the low concentrations produced by powerplants, they produce no adverse effect on the atmosphere. In special situations where particular hydrocarbons are available from sources other than powerplants, there is some evidence of the formation of irritating compounds; and, again under special conditions, these may become concentrated to the degree that real problems exist.

Some work has been done toward the direct elimination of nitrogen oxides by changes in the methods of combustion. Two methods of adjustment to the problem, however, seem more effective in producing the desired final improvement. It appears likely that the control of the volatile hydrocarbons, which is a desirable end in itself as far as air pollution is concerned, will solve any problem associated with oxides of nitrogen emitted from powerplants. Under nearly all meteorological conditions, high stacks are of considerable help in diffusion of these gases and preventing their interaction with the hydrocarbons.

NEW DEVELOPMENTS

Beginning about the middle 1950's the utility industry has shifted very rapidly to generating units of a size that were not seriously contemplated a decade ago. Figure 1 shows the amount of steam-generator capacity in each of three size categories purchased since 1948. At the beginning of this time, steam generators rated less than 1 million pounds of steam per hour constituted 100 percent of the market. This size of unit has suffered an almost steady decline, until in 1962 it represented only about 15 percent of the capacity sold. For the size between 1 and 2 million pounds of steam per hour, the chart shows that they rose from nothing at the start of the period until they achieved 70 percent of the market in 1953, and have since been

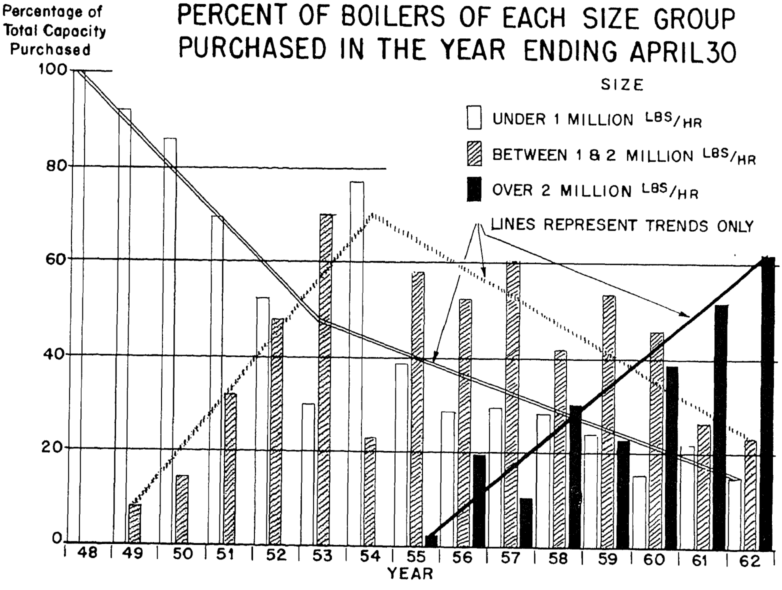


Figure 1

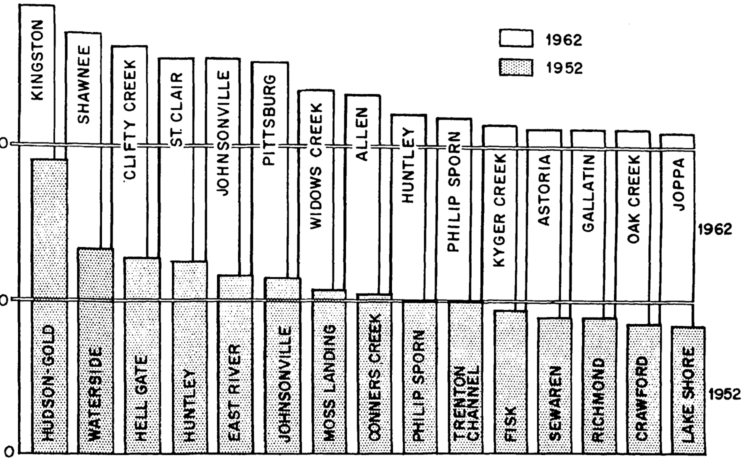


Figure 2

in a steady decline. Steam generators in the over 2-million-pound-per-hour size began to appear in 1955 and by 1962 they came to represent slightly over 60 percent of the capacity sold. It should be remembered that units sold in 1960 are just now coming into service, and therefore the full effects of this trend to larger units are still to be felt. Similar trends could be shown for the size of turbine-generator units purchased in this period, since nearly all were constructed on the unit system, that is, a single boiler serving a single turbine without cross-connections to other units in the plant.

Along with the tendency to install larger units, the industry also has witnessed a rather sharp increase in the total amount of power installed on one site. Figure 2 indicates the relative sizes of the 15 largest thermal plants in the United States in 1952, and above them are plotted the 15 largest plants in operation at the close of 1961 as reported by the Federal Power Commission. While in 1952 the largest thermal plant did not quite reach 1,000 megawatts (Mw) in size, there are today 15 plants which exceed that mark, one by as much as 40 percent.

The advent of plants well above 1,000 megawatts has brought a new problem or a new dimension to the problem of proper disposal of the stack gases. Heretofore, the air pollution problem confined itself principally to the area immediately surrounding the plant. Assuming that adequate elimination of particulate matter was accomplished, and that by wind tunnel studies the stacks were chosen of a height that prevented aerodynamic downwash due either to the plant structure or to terrain features, there was little reason to fear that a plant of 400 to 500 megawatts would become a community problem.

These simple precautions are no longer sufficient for the new group of very large plants, although they must of course be even more carefully followed. Beginning with the design of Clifty Creek plant of roughly 1,200 megawatts output, the selection of stack heights has become a matter of a great deal of study and one requiring contemplation of many variables. These would include:

(*a*) Study of the adjoining terrain.
(*b*) Land use in the area.
(*c*) Population density.

(*d*) General and particular meteorological features.

(*e*) Aeronautical factors.

(*f*) Fuel or fuels to be burned.

(*g*) Stack gas exit velocity and temperature.

(*h*) Gas diffusion studies for volumes involved.

Some of these can be considered together by the use of the Bosanquet, Carey, and Halton formulae for gas rise, and those of Sutton for its diffusion. Such calculations bring together the effects of sulfur content of the fuel, gas exit velocity, gas exit temperature, and the mass flow involved; and relate them to a stack height and to some resulting sulfur dioxide concentrations at varying distances from the stack under various meteorological conditions. These processes are iterative and, in the absence of modern computers, were extremely tedious. By necessity the Clifty Creek stacks had to be based on a minimum number of such calculations. The stack height selected for Clifty of 683 feet above grade represented a combination of:

(*a*) The diffusion approach for the more distant areas.

(*b*) A wind tunnel study of difficult terrain feature, only 2,500 feet from the plant.

(*c*) Finally, a slight compromise to satisfy the Federal Aviation Agency, although the plant was over 40 miles from the Louisville airport.

Thus, on one site there was an illustration of all of the factors which enter into determining the stack height for the larger plants now coming into being. Construction of these stacks was followed by the installation of a number of SO_2 analyzers and dustfall stations, which proved that the actual results were appreciably better than predicted by the design calculations. Even more gratifying, from a community relations standpoint, has been the fact that in the nearly 7 years of operation, not a single air pollution complaint related to these stacks has been received. The Clifty stacks and those of the sister units at Kyger Creek plant were instrumental in setting a trend toward effective high-level dispersion of stack gases.

In addition to the checking of results at Clifty Creek and Kyger Creek plants, the diffusion equations have been verified at several other locations. The area around two of the large TVA plants has been extensively studied by special techniques, such as gas sampling along the stack plume by means of helicopters, installing a network of ground-level SO_2 recorders, and carefully recording the meteorological data for the region. This work has shown a high degree of correlation between the predicted and the actual results. Since 1958 the diffusion studies have been arranged for solution by digital computers, and the way has been opened to make extensive studies before building any plant. As a result of such studies there is a growing appreciation of the part that gas temperature plays in producing adequate plume rise from very large plants. At the same time, there has been some lessening of dependence on high exit gas velocity to solve problems.

In engineering, as in other phases of life, the solution of one problem may only serve to bring another into being. While the high concrete stack accomplished its air pollution function in a highly satisfactory manner, the utility industry is now faced with the problem of sulfate attack on some of the concrete stacks built since 1954. The best available study of the problem does not bring out any

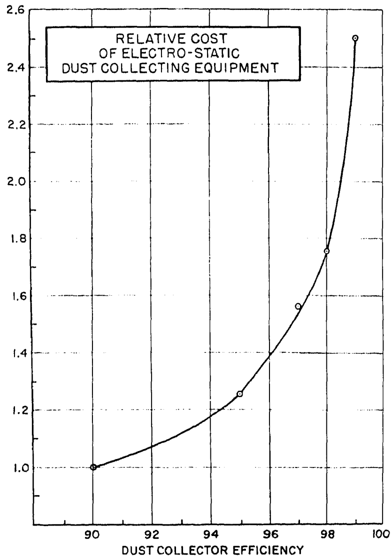


Figure 3

tion, many companies in their new designs are resorting to either an independently supported brick lining with a ventilated space between it and the shell, or to a free-standing, insulated steel lining within the concrete stack. Either of these two steps involve a considerable extra cost for disposing of the flue gas. Particularly heavy expense has been incurred in cases where existing stacks had to have liners added after several years of service. Some believe that as exit gas velocities were increased, a situation of positive pressure in the stack was created, and this change to positive pressure from what had heretofore been a suction condition resulted in accelerating the action of the sulfur oxides on the concrete. This general supposition is not borne out completely by the study of the available

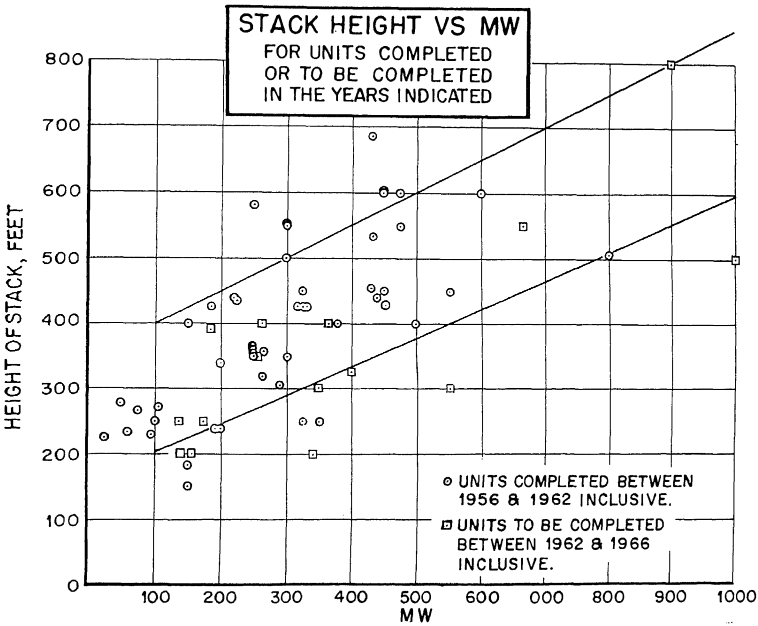
of this problem, which has come about as a corollary to improvements in the air pollution situation.

The trend toward ever tighter control of particulate matter has been mentioned. While we are fully in accord with the central portion of this trend, there are some points which the author feels can react unfavorably on the public we serve, without providing it with any significant improvement in air pollution. These points are:

(*a*) Imposing limits that may be beyond any economic justification for large units, while setting much less drastic limits for numerous small units that may actually be creating much more of a problem.

(*b*) Overstressing of the appearance of the stack effluent, a criterion which as stacks in-

Figure 4



particulate matter emitted.

(*d*) Apparent disregard of the mounting cost and size of equipment as absolute perfection is approached. Figure 3 shows this effect for electrostatic dust collecting equipment.

Items (*c*) and (*d*) combine to have a particularly adverse effect on the powerplant designer, since he is barred from balancing dollars spent in two different ways to produce the best overall result. It should be evident that the utility industry can do many things to satisfy public requirements. The public should, however, at the same time be aware that increased costs from nonproductive facilities ultimately will be borne by them in the form of higher rates. In simple justice to the public, those who seek to establish limits should leave the door open to producing the overall result in the most economic manner.

CONCLUSION

The principal new factor affecting air pollution from powerplants and its control that has appeared in the past decade is the shift to larger individual units and to larger total plants. Figure 4 shows the stack heights, and the capacity of the coal-fired units which they serve, for a number of plants built

ward trend in stack height is unmistakable, although differences in plant sites, fuel burned, population density, proximity to airports, and possibly other variables, create wide individual differences among the plants.

It can be seen that the power industry observed this new factor and promptly moved to maintain optimum community relations, by disposing of the vast quantities of gases from these new plants in a highly satisfactory manner. This has involved stacks which were larger than any previously built in the United States, such as the 683-foot structures at Clifty Creek. Structures of this magnitude introduce new problems in both their construction and maintenance, as well as adding significantly to the original cost of the plant. The forward-looking utility accepts these costs and design problems in full knowledge of its community responsibility.

It is our feeling that the freedom to approach these problems openly and honestly, seeking for an optimum solution which includes due consideration of the community, the rate-payers, and the stockholders, is a valuable one. This freedom should not be lost to those who would promote arbitrary regulation in a field which has developed, and apparently will continue to develop, as rapidly as this one.

Prepared Discussion: AIR POLLUTION FROM POWERPLANTS AND ITS CONTROL

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Mr. Frankenberg has given us a brief but very lucid account of the steps taken by the electric utility industry to keep pollution within a limit acceptable to the communities it serves. The problem of balancing economic factors against excessive control is clearly brought forth, and we agree that this needs to be stressed in the consideration of any air pollution problems. Just as new developments in commercial techniques and equipment indicate the need for review of our standards, likewise, the ever-increasing size of powerplant installations poses problems that may require periodic reappraisal of previously acceptable standards.

On a year-round basis, energy released by combustion of coal, petroleum, and natural gas, the so-called fossil fuels, powers about 82 percent of the electric generators supplying this Nation's vast electrical-energy market. Projections of electric energy demand indicate that the past tendency for it to double roughly every 10 years can be expected to continue through the remainder of this century; other projections indicate that fossil-fuel consumption will continue to rise almost in proportion, at least for the next decade or so. Thereafter, nuclear energy release may begin to be a significant and steadily growing factor. Even so, projections show increased fossil-fuel consumption throughout the remainder of the present century. Because the Bureau of Mines has a number of responsibilities concerning production, processing, and utilization of fossil fuels, we have a keen concern in their relation to air pollution.

To the extent that added conventional thermal powerplant capacity is installed and operated in or near urban areas, it will tend to add some increment of pollutants to the surrounding atmosphere. Production of nitrogen oxides is common to combustion of each of the three kinds of fossil fuels. Production of sulfur oxides is common to combustion of petroleum products, especially residual fuel oils, and to combustion of coal. We have much to learn yet about the more subtle roles of these oxides in urban air pollution although we can accept categorically that, in sufficient concentrations, they can impair man's health and degrade his property. Still other pollutants of significance may be present in powerplant stack emissions, but we don't yet know. I should hasten to add that there is a lack of general agreement among medical experts on the significance of man's breathing air that contains small amounts of nitrogen and sulfur oxides. I should also point out that powerplants are by no means the sole source of nitrogen and sulfur oxides in urban atmospheres. Powerplant management characteristically tends to protect the area it serves from adverse effects of powerplant stack emissions. A review of the industry's plant locations and equipment installations, and its history of concern and action over air pollution problems, attest to this.

The electric utilities industry has always been in the forefront of the industrial community in its efforts to reduce stack emission of air pollutants to acceptably low levels. Obviously, the principals know, and the public should know, that a large part of the costs involved in stack emission control will eventually be passed on to the consuming public. Admittedly, electric utility companies have an advantage over many other industries in their communities in that it is possible for them to cover the cost of improved operational controls through

an increase in the price of their product, provided they can convince the appropriate public utilities commission of the necessity for such increases. Nevertheless, I need not tell you how "cost conscious" the public utilities are; their record of holding the price line in the face of inflation is testimony to their efforts.

It is perhaps fortuitous that the major industrial consumer of fossil fuels should be thus favorably situated. However, let me hasten to add that electric utility management cannot be, and indeed does not try to be, complacent and self-assured in this matter. Being an industrial neighbor, often the principal industrial neighbor, of residential areas is no sinecure. And, a sincere desire by electric utilities to discharge relatively pollutant-free stack emissions is not tantamount to attainment. Where tools are available for economic control, electric utilities use them. Thus, smoke and flyash from utility company stacks are rarely problems in these times. On the other hand, where are the tools for economic control of sulfur and nitrogen oxides? And, for that matter, just how much control is needed? The former question is of direct concern to the Bureau of Mines, because it involves a problem related to consumption of the three major fossil fuels.

As previously indicated, the sulfur oxides problem is one that will be with us for a long time. The removal of sulfur-bearing compounds from coal or oil is both difficult and costly. Considerable progress has been made in coal preparation methods that are effective in removing part of the sulfur-bearing materials. Economically feasible methods for removing sulfur oxides from the stack gases have not, as yet, been developed.

Recognizing a widespread and difficult problem concerning a phase of minerals-use technology, the Bureau of Mines is doing something about it. Jointly with the Public Health Service, and through support they provide under Public Law 84–159 as amended, we are presently investigating in cooperation with certain utility companies the composition of flue gas in large coal-burning steam boilers. Additionally, through cooperative-fund agreements with PHS, we have been developing and studying the operational and economic feasibility of a "dry scrubbing" procedure. We also are looking into the effect of this and other possible economic means for lowering the nitrogen oxides content of flue gases. We hope that we can play an important role in better elucidation of what it is we are concerned with, and how we best can deal technologically with whatever components of powerplant stack emissions need source control. When a rough sketch of the tools that are really necessary can be drawn, I am confident that equipment makers will be quick to pick up, perfect, and produce those tools for economic control, and that powerplant management will be ready customers for the product.

… FROM THE MUNICIPALITY AND THE HOME AND ITS CONTROL

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In order that there will be no misunderstanding, let me first explain that when we say "home," we are actually speaking of all residential properties, ranging from the one-family home to multiple-apartment dwellings and hotels. Air pollution attributable to homes originates with two basic operations. These are the operation of heating plants and of refuse disposal or incineration equipment. There are air pollution problems encountered in residential properties which are minor from the point of view of the infrequency with which they may be encountered. Under certain circumstances, however, they may actually approach major importance. These are usually the nuisance type of condition, resulting, for example, from the poor placement of ventilators in buildings with basement garages. More and more such buildings are being built around the country today and, because existing legislation is not geared to this type of problem, obtaining correction is often a cumbersome or difficult operation. Other examples are the discharge of lint, odors, steam, and so forth, from such domestic devices as domestic clothes dryers or air conditioners. Then, of course, there is the problem of dust emissions encountered during the construction or demolition of residential and other properties. Occasionally an odor problem is encountered when the vent pipe on an oil storage tank is improperly placed, leading to an odor nuisance at the time when the oil tank is being filled. Most of these nuisance type conditions can be corrected by either relocation of the point of emission, or of the device itself to a location where it will not be a nuisance to its neighbors. Some of the dust incidental to construction or demolition of buildings is almost unavoidable, but a good deal of it can be controlled effectively by proper operation. The construction of tight chutes for disposal of debris will prevent loss to a good degree. The prompt and thorough use of hoses for the wetting down of materials also will help. The proper use of tarpaulins as wind baffles also will, in many cases, provide a solution to such problems. Proper supervision of trucking to and from the construction or demolition site, to insure that trucks are not overloaded, is important to avoid dust nuisances.

Since many residential properties are of the mixed occupancy type that includes stores and other retail establishments, we have a host of air pollution problems originating purely from the various types of businesses that may be found in such buildings. Restaurants, laundries of either the commercial or coin-operating type, coin-operated or conventional drycleaning establishments, fish markets, and so forth, all are illustrations that I just mention in passing. Since they are only incidental to the operation of residential properties, and then only occasionally, I will go no further along these lines.

Many municipalities now are operating residential housing properties, and therefore find themselves in the peculiar position of having one agency operating properties that create pollution, while another agency of the same municipality is charged with responsibility for reducing and controlling air pollution. Even more frequently, municipalities contribute to their own air pollution problem from the operation of sewage treatment plants, asphalt plants, incinerators, powerplants, vehicles used in public transportation, and similar installations. From what I have seen and heard in some areas, the public may be justified in saying that the municipality gives private enterprise pretty close competi-

to make a profit. This, of course, is not the case with the municipality that owns or operates properties of various kinds. The municipality finds itself "in business," if I may use that expression, because of the need or the desire to be of service to its public. If Caesar's wife must be above reproach, a city-owned installation should also be above reproach. The substandard city-owned installation puts its air pollution control agency in an unenviable position, for reasons that are obvious. Incidentally, a slightly paradoxical situation prevails. A municipality that does *not* operate a public incinerator, powerplant, or sewerage treatment plant, still may be responsible for air pollution by virtue of the fact that such services are not performed by them. The city without an effective public refuse collection and disposal system, for example, leaves homeowners with little alternative but to employ backyard incineration as a means of disposal. It is unnecessary to tell you how much of an air pollution problem backyard incineration can create in a city. As a further illustration of this paradox, where adequate and effective public transportation facilities are not provided, the public will use private cars, and then roadways are choked with traffic, and the atmosphere is choked with exhaust fumes. Now let us look at the other face of the paradox. Where the city has public transportation, pollution problems are created by the diesel buses that it operates, or by the powerplants required to generate the electricity to run its transit system. Where the city provides municipal refuse collection and incineration, air pollution frequently is created from the operation of large incinerators. Any air pollution control official, however, if given a choice, would much rather contend with air pollution originating from a few large plants than from a multitude of smaller sources of pollution. It is easier to maintain control over one city incinerator than over thousands of small incinerators scattered throughout the city.

Getting down to specifics, the methods for the correction of air pollution from boilers are pretty well known. The past half century of engineering progress has made available the knowledge, and the wherewithal, to solve practically any air pollution problems stemming from boilers. The control agency that has a legally effective permit and control system is prepared to prevent or to minimize new local sources of air pollution. Taking steps to the installation has been made, however, the job does not end. Steps must still be taken to insure that these boilers are properly maintained and properly operated. It is routine for the careless or stupid fireman to upset all the good work that the engineer and the manufacturer have put into the construction of the boiler. There may be a time in the distant future when boilers will be so designed and automated as to eliminate completely the factor of the human element. Perhaps, even before that day arrives, atomic energy, as a source of heat and power, may render boilers obsolete. But we can't sit back and wait for the millennium; today's problems have to be solved today. Solving a problem involves two steps. First, analyzing the problem and ascertaining the cause; and second, getting the cause of the problem corrected. This sounds simple, doesn't it? But before anybody in the audience tells me that this is not simple, let me say for the record that I know it is not always a simple matter to find the cause in many cases. The control agency must have its own staff make a careful survey of the problem; in other cases, the owner of the offending plant must be required to call in his own consulting engineer to study the problem, and there are many cases where both steps may take place simultaneously. No general rule can be laid down as to the method of approach, since circumstances vary from one community and situation to another. Once the cause has been ascertained, then several techniques or a combination of techniques may be employed in getting the cause corrected, such as cooperation, persuasion, education, or enforcement. It is not at all unusual to encounter a situation where the property owner has no knowledge of the fact that he is causing air pollution. Apprising him of the fact and appealing to his moral responsibility or civic pride should suffice, and often does, to gain correction. Where a little extra persuasion is needed, simple arithmetic showing him in dollars and cents how much he is wasting by the incomplete combustion of his fuel should get the necessary work done. Incidentally, it is rather difficult to convince the general public that every smoking stack is not really smoking out of malice aforethought. From my own experiences, I have found that on a great many occasions the offender is completely unaware of his offense until the control official brings it to his attention.

getting causes of air pollution corrected is a twofold tool. It can be employed for preventive as well as corrective measures. By education, I mean far more than the direct instruction of one individual on one problem. The preparation and distribution of little educational leaflets or pamphlets on the various aspects of proper maintenance and proper operation provide an important tool. Incidentally, where availability of funds may be a problem, it is sometimes possible to get the cost of printing taken over by some other public-spirited agency, organization, association, or manufacturer. Press releases to all agencies of public communication such as newspapers, radio, and magazines are an important technique. A more formal type of educational approach, which does require a little more effort, may be indicated in some cases. For example, the New York City Housing Authority, which operates many residential properties in the city of New York, has conducted regular classes for its custodial employees. Our health department has also conducted formal classes for janitors and superintendents. The better informed operator of boilers is less likely to cause air pollution from his equipment.

Last, but certainly not least, is the enforcement technique. The enforcement technique employed may range from warnings through violation notices, departmental hearings, summonses, or even the sealing of equipment. Earlier I mentioned that the methods for control of air pollution from boilers or for the correction of the causes of air pollution from boilers are pretty well known. This is not equally true of incinerators, although there has been, in recent years, a tremendous amount of research on this subject. Not only has there been much progress in the design of incinerators for special functions, but there has been a great deal of improvement in the design of incinerators intended for residential property use. Despite this, however, there still remains a need for a great deal of additional research in the field of proper incineration. Particularly on the subject of methods, the munic-

informed of all the latest developments, and by using the information thereby gained to the fullest extent in solving such problems as they may have. The control official must, when confronted with a problem originating from a municipally owned residential property, be just as diligent, if not more so, in seeking correction as when privately owned property is involved. It is far easier to convince the owner of private property that he should be cooperative, when he knows that lack of cooperation on his part may lead to a summons and a fine. This spur to cooperate is not present with the municipal offender. I would like to remind you that the word "cooperate" implies a mutual operation for a mutual objective. Cooperation is not a one-way street. If a municipal offender is expected to cooperate with the control agency, then it is the obligation of the control agency to cooperate with the offender. This means most often that you must be prepared to assist him in any way you possibly can, in his approach to the city fathers, to enable him to convince the "holder of the purse strings" that funds or manpower must be allocated to effectuate correction of the air pollution problem. It is not always possible for the municipal air pollution control agency and the municipal air pollution offender to get together on a plan or program to correct an offensive condition.

In such cases, it is the responsibility of the top municipal administrative head to evaluate the problem and then to take prompt, decisive, and effective action. It must be freely admitted, as I have inferred previously, that disagreements between municipal agencies occur everywhere, and that a strong hand is necessary to resolve the difficulties. These instances are equally applicable to Federal, State, regional, or "Authority" jurisdictions, which are not responsible to each other at the same or at different levels. It is not always simple to adjudicate these disputes and the methods of doing so could well be the subject of a paper longer than this one.

Prepared Discussion: AIR POLLUTION FROM THE MUNICIPALITY AND THE HOME AND ITS CONTROL

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A 1961 survey of local air pollution programs underway in the United States showed that 119 urban places with more than 50,000 population were engaged in programs to control and prevent community air pollution. The primary emphasis in most of these activities is concerned with controlling discharges into the atmosphere that are creating nuisance conditions. These complaint situations originate from the effects of relatively large sources, such as heavy industrial plants, like a steel mill, foundry, oil refinery, or an open burning refuse dump or industrial metal salvage operations.

A relatively few community air pollution programs are now organized and staffed to effectively control areawide effects resulting from multiple source discharges into the community atmosphere. It is not too surprising that this is so, if we recall the sequence of past events which led to the initiation of the community air pollution program. In most cases, these actions have stemmed from an accumulation of public complaints about continuing nuisance effects from industrial sources of air pollution or at least the effects caused by a relatively few large suspected sources in the community. Usually the initial effort of the community program is to control the smoke and dust discharged from the large individual industrial sources. Until recently, little attention had been directed towards determining what kind of areawide atmospheric purity was desired by the community.

Frequently, air pollution from the municipality and the home has been lightly treated since there were other much larger sources, where, for a given amount of control agency staff time, a more significant source reduction could be produced. Generally aggressive citizens' complaint actions have demanded abatement actions of the large known or suspected sources. I am sure that most participants in this Conference would agree that the air pollution sources within the municipality's operations and the home should receive high priority for required control actions so that the municipality would then provide real leadership towards effective air sanitation in the community. However, this very logical approach has seldom been used; in fact, the ordinances adopted in many communities exclude the air pollution from single or from two- to four-family units from the regulatory requirements. Also, many cities with fairly active industrial air pollution control programs still permit the open burning of community refuse and allow the installation and operation of inadequately designed incineration equipment. Later, the community discovers that the desired air sanitation conditions were not achieved solely through the control of its large industrial sources and other large individual emissions. Many comprehensive community surveys have established that the total air pollution from the space heating and refuse disposal sources are a relatively large percentage of the total burden placed upon the atmosphere in the community.

In a few localities, public educational programs have been effective in gaining understanding that communitywide control actions are essential to produce the desired level of air sanitation. It would be delightful if the experiences of these communities were easily transferable to other urban loca-

information and education probably could achieve a higher degree of public acceptance. Then one might expect that a well planned and supported educational program would automatically be one of the first activities in establishing a community air sanitation program. Although this is logical, it does not happen routinely. Usually the public educational effort follows along some time later, particularly to generate public support for extending the air pollution control activities after it has been demonstrated that control of the individual sources has not produced the desired results.

Looking toward the future, it is probable that increased emphasis will be placed upon air pollution sources from municipal operations and the home. The steady addition of new industrial and commercial facilities which include effective control systems will in time make the air pollution discharged from the municipal operations and the home appear relatively larger as an important community source. Also, the rapid development of ambient air quality regulations will serve to define and identify more clearly the need for increased communitywide activity. However, there will be continuing difficulties in obtaining adequate budget increases to provide needed expansion of the community air pollution program. At present the growth in local programs is not at all adequate to meet the needs; in fact a 1962 report by Jean J. Schueneman showed that little or no headway has been made in the last 10 years, except in California jurisdictions, to bring the resources of local air pollution control agencies to the level that is needed to cope with the problem. During this 10-year period, about one-third more personnel were employed but the 30-percent increase in urban population offset any real gain in resources. Competition from other governmental needs is great.

A new approach toward the financing of local air sanitation programs is critically needed. If a grant-in-aid program is authorized by the Congress, some stimulation of program development would follow; however, the rate of growth from this stimulus alone probably would not be enough to satisfy the increasing public demand for reasonable air quality conditions. Then what is the answer towards organizing adequately financed community programs?

During the 1958 conference on air pollution, Dr. R. A. Nisbet presented a report on the impact

pollution control was needed to establish the stake of the community and the neighborhoods in the community in the struggle for clean air. He suggested that women in the upper middle economic groups, preferably in the 20–50-year age category, would be the most effective persons to energize the need. He stressed the need for two-way communications between the community action groups and the local operating agency concerned with air problems, needs, and activities. If air pollution from the municipal operations and the home is to be adequately controlled, then new emphasis and drive from the community itself is overdue. The administrator of the community air sanitation program should devote part of his time to the formation and servicing of local action groups; however, I know that the day-to-day demands upon the official's time does not stimulate his initiative to deliberately pursue activities of this kind, since it creates a need for followup and, in time, some criticism of the agency's program activities. However, the local official's overall responsibility to inform the public regarding air pollution conditions and needs really should make such activities mandatory.

Now let's assume that the community has a well-informed community action group in support of the local air pollution agency. This accomplishment will not itself assure that adequate budgets will be forthcoming. The severe limitations of the local tax base to finance a multitude of other community needs like schools, fire and police protection, urban renewal, water supply, sewage treatment, and welfare programs, will severely limit the realistic financing of the air pollution community activities. Obviously, continued pressure from the action group will increase the funds each year, but without some kind of a local crisis, the annual increase probably will not be sufficient to support an effective overall air sanitation program.

It appears then that a new approach to obtain adequate budgets for community air quality programs is needed. An analysis of the possibilities of new financing could be the subject of a separate paper, by a specialist in such matters, but some of the desirable elements of the financing seem clear. It should have a relationship to the community activities that create at least part of the basic air pollution problem. It should have a built-in fea-

ture of growth so that, as population increases and industrial and commercial activities grow, the funds for the air pollution program would also increase without an official action of the city council or other local tax body. One possibility would be a modest tax upon fuels used for space heating and power generation, such as oil, coal, or gas. Another approach that has a relationship to air pollution would be a tax placed on each gallon of gasoline and diesel oil.

CRITIQUE

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The planning committee for this session scheduled this paper to serve as an introduction to the discussion period. In a sense, all of the discussions at this conference are critiques. A definition of critique is "a critical discussion of the execution of a problem." The problem presented to this conference is how to stimulate action to clear the air.

As a governmental air pollution control officer and an advocate of clean air (which is a somewhat redundant statement), it is my job to continually and critically evaluate air pollution problems and abatement programs. Therefore, basing my comments on experience (and not intending to be sacrilegious), I would like to discuss the first two papers—Bishop's comments on Faith.

Dr. Faith stated that "most industrial pollution problems are susceptible to economic methods of control." Dr. Bishop presented a graphical representation of the economic factors to be considered in determining if and when controls are to be instituted. I believe that it should be noted that the "Cost of Air Pollution Damage" also includes the loss to the community of new industries and tourist trade.

It is obvious from Dr. Bishop's graphical presentation and Mr. Frankenberg's paper that the cost of damage decreases exponentially, and that the cost of control increases exponentially, with increasing degree of control, for example, collector efficiency. The various factors affecting the choice of a level of control are not equally weighted. The relative weights given to these factors also vary among various industrial plants, as pointed out by Dr. Faith in his discussion of the economic problem. There is another exponential factor which I believe should be noted.

Recognizing the limitations of this type of subjective discussion, I should like to submit an empirical equation which I believe may describe the view taken by some industries:

$$P = \frac{K}{M^m}$$

P is the probability that air cleaning equipment will be installed on a certain process. It can also represent the efficiency of the air pollution control equipment installed (since it is reasonable to expect that if the chances are good that control will be effected, it is probable that a good job will be done). The value of K depends upon a number of factors:

1. The severity of the air pollution problem caused by emissions from the process.
2. The value of the material (dust, fume, etc.) recovered from the gas stream to be cleaned.
3. The existence of governmental air pollution control regulations and, as pointed out by Commissioner Benline, the degree to which cooperation, persuasion, education, and enforcement are employed.
4. Whether or not there are similar successfully operating installations.
5. A nebulous item known as "company policy." This item is related to Dr. Faith's discussion of "enlightened public relations . . . absentee management . . . deep-seated distrust of governmental controls."

M is money (the cost to the industry) and is a function of the gas volume to be handled, the difficulty in separating the contaminants from the gas stream, and other factors such as maintenance, power requirements, and corrosion. m depends

upon the financial condition of the company or "the state of business." In some cases it can be considered as having a value equal to the reciprocal of the company's most recent stock dividend. The heavy weight given to economic considerations is understandable since often air pollution control does not enter directly into the process or contribute to the plant's final product. Thus gas cleaning may involve expenditures with no expectation of profit.

I believe that *m* reflects an attitude which has been prevalent for a number of years but now seems to be changing. That is, the consideration of air pollution control devices as unproductive appendages to the plant. Air pollution control was given priority after the parking lot was repaved and flower pots were put in the guardhouse. This attitude has led to air pollution control equipment receiving poor maintenance. Economic factors, involving the possible uses of material removed from process emissions and the necessity of providing for air pollution control prior to plant construction, were ignored.

Smith Griswold recently stated:[1]

> The air pollution control process begins with a set of determinations which define the level of air quality desired in any community. These determinations involve questions of fact and value; they involve a partnership between science and philosophy, and between administration and politics. They involve questions of health, of esthetics, of economics, of engineering, and of law. There is no magic formula, no automatic process, no simple mechanical step which results in a proper determination of the kind of air quality a community should enjoy.

I believe that the papers delivered at this session have clearly brought into public view many of these questions.

[1] "Community Approach to Air Pollution Control: The Role of the Control Officials." Presented at the 55th Annual Meeting of the Air Pollution Control Association, Chicago, Ill., May 21, 1962.

reference to the multiple incinerators in domestic installations. There has been so much progress in the design of domestic incinerators that they should be considered as air pollution prevention devices. I'm referring specifically to gas-fired incinerators which are approved with an American Gas Association label and designed to American Standard Association's specifications. They do an excellent job and they may be a fine solution for on-the-site disposal of refuse and eliminating traffic problems in collection, as well as the many backyard fires from so-called incinerators which are nothing more than wire baskets. Would this not be a solution to the disposal problem of combustible refuse?

Benline. We are very much in favor of certain types of incinerators, and a gas-fired incinerator such as Mr. Goder describes is highly useful. On the other hand, there are certain gas-fired incinerators of the domestic type which prompt the housewife to say, "Well, I like the gas-fired incinerator, but let's not spend too much money." So she turns it off quickly and lets it smolder for the rest of the day. In addition to Mr. Goder's product, many other incinerators are also highly desirable. Most cities would not be able to handle refuse without them. On the other hand, as Mr. Goder knows, our interest is in trying to operate and to improve them.

Benjamin Linsky. Let me first read a statement prepared by the board of directors of the Bay Area Air Pollution Control District and endorsed at a preconference meeting of significant California interests, including the State Association of County Supervisors, leading California cities, and many industrial groups, as well as our air pollution control districts.

> (1) The U.S. Congress should adopt legislation permitting the rapid tax writeoff of investments made by private concerns in nonproductive air pollution control equipment.
>
> (2) The Federal Government should require, as a condition of Federal financing, that projects they help pay for should fully conform to antipollution control requirements of the communities in which they are located or, preferably, at all locations in the United States.
>
> (3) The planning agencies and planning educators should be encouraged to utilize available techniques that incorporate practical air

I might point out that the second point applies to such Federal operations as the urban renewal projects to which Mr. Benline referred, to public housing projects, roads, and clearing for roads, and government-owned and contract-operated plants and installations of many types. To illustrate our third point, I just talked with a papermill operator. It is recognized that it is desirable to have a "protective band" around a papermill; there isn't one in the world which has learned how to control its odors so that the thresholds are closer than 10 miles from the gate. Within such a protective band, perhaps active recreation could be carried on, even if not the picnic type, since the odors might not mix well with bread and butter. This kind of realistic zoning, which has sometimes been called defensive zoning, we think is worth consideration.

Now I have two questions for Mr. Bishop. First, how much is it worth to see 20 miles on a sunny day instead of having the sparkling view smudged up by visible dirt? One hundred pounds an hour of microscopic dust from a small uncontrolled open hearth furnace ruins the view for 1 to 2 miles as a distinct zone of decreasing haze. Second, we have case histories of clean plants that stayed out or moved out of polluted industrial areas because they couldn't stand it, so-called precision and scientific industries. Do you know of any plant that has ever shut down or moved out of a community because of community air pollution control regulations? In 14 years I've been able to accumulate just two case histories of that type where air pollution control requirements were even a significant factor.

Bishop. The first question can be reworded: What is a room with a view worth? All of us know that, every day, added value is placed on a room with a view. At an Atlantic City hotel a room that overlooks the ocean has a higher price than the room that overlooks the city, and a room that overlooks an elevator shaft comes at an even lower price. This concept is one used every day in industry, and in the home; even if the wife has a pair of curtains that suits her husband, she goes out and buys a new pair because they look better. She's putting a value on the view and I'll admit that it's much easier for an individual to decide what the view is worth than it is for a community. But it seemed to us in our deliberation at Michigan that by making a survey,

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a community could get some idea of what its people thought a view was worth. We appreciate as you do how helpful it would be to have some absolute value but we must, as we do in every job, use all the definite facts we can get and finally come up with the best estimate we can for the value to the community of the view.

Now for the second part of your question, which is a little more difficult: How many plants have done what because of air pollution? My own feeling is that a great many companies take air pollution very seriously in their consideration of future plans. These include air pollution abatement equipment costs, changes in operations, and so forth. I don't know how many plants have actually moved. A number of plants have actually abandoned processes which they felt were too difficult to clean up. I think many industrial people today are having discussions within their own company, on plans for a piece of equipment, say 20 years old, with a few more years of useful life, which would require a good deal of pollution abatement equipment. It's obviously a little difficult to put new abatement equipment in a plant which has a short life. In some instances such a crisis will lead to abandoning equipment with life left in it and changing to some other operation, whether it be in the same city or in other locations. If we move too rapidly in insisting on cleaners, it means the abandoning of equipment with good economic life. If we move slowly enough we probably can phase out the old operations and phase in the new without too many difficulties.

J. O. Julson. I was much intrigued with the formula Mr. Sussman developed in his paper. So, after much burning of the midnight oil, I devised a little formula of my own which I think applies to my own company, which operates a kraft paper mill in Oregon. I have used Mr. Sussman's basic formula and some of its elements to derive a new formula. I believe it portrays how the individual elements would affect the probability of obtaining corrective action in air pollution problems. This formula is presented as an alternative to that suggested by Mr. Sussman and for the record. It represents the elements which my company feels would most surely achieve the goal of this conference, "Let's Clear the Air." My formula is this: $P=\frac{K}{M-W}$. P represents the probability that corrective action would be taken. K represents a number of factors, the accurate evaluation of the degree of severity of the air pollution problems caused by emissions from the source + the value of material such as dust, fumes, and so forth recovered by corrective actions taken + the existence of fair and realistic local air pollution regulations + the existence of fair administration of those regulations + the existence of successfully corrective installations + the economics of the polluter as affected by corrections required under local regulations. M stands for the net money required to effect correction; and W is made up of two factors as pointed out in Mr. McAfee's paper yesterday. One is control for control's sake alone; the other is the existence of regulations and actions of regulatory authorities which go beyond the corrective action really necessary. As to the workings of this formula, I feel that you get the most action in correction of pollution when you encourage the factors in K, and that you would be adversely affected by the expense required to effect correction. Certainly, corrective action will be adversely affected if we reach the point where people start fighting one another instead of seeking cooperative action.

DeYarman Wallace. I would like to take this opportunity to compliment Arthur Benline on his paper. All too often industry is pointed out as the culprit in air pollution, when the individual and the home can and do in the aggregate contribute materially to air pollution. This is often overlooked. The city of Pittsburgh was cleared of air pollution because the homeowner switched to smokeless fuel. It was then that the citizens of Pittsburgh discovered they had an industry in the valley. I agree with Mr. Benline that no general rule can be laid down as to a method of approach which can be applied to all media which may contribute toward pollution of the atmosphere.

Joseph W. Mullan. The words "heavy oil" are omitted from Mr. Faith's discussion. Certainly the inefficient burning of heavy oil will also make smoke. And in California, gas has replaced heavy oil in numerous instances to reduce pollution. Efficient burning of heavy oil can yield No. 1 Ringelmann; efficient burning of coal yields 0 to ¼ Ringelmann. Would Mr. Faith like to comment?

Faith. Mr. Mullan is correct. Heavy oil burned inefficiently will produce smoke the same as burning any other fuel, just as the inefficient burning of light oil produces smoke. I was trying to point out the chief problems by mentioning coal, waste, and wood, not the chief potential problems such as

large powerplants have long recognized the problems of air pollution and have solved them to a remarkable degree. However, the volume of stack emissions is ever increasing and represents a growing problem even with the best available air pollution control equipment. An ideal long-range solution would be the complete elimination of stack emissions. The atomic electric-generating plant offers just such an opportunity. In fact, a stack becomes virtually unnecessary, since the design of the nuclear reactor has reached such a high degree of control that the release of any effluent, radioactive or otherwise, can be almost completely eliminated, due to total absence of the products of fossil fuel combustion. The nuclear powerplant, unlike the atomic bomb, does not liberate radioactive fallout. However, some interpretations of existing regulations governing atomic powerplants have militated against the location of such plants in urban areas where they could contribute to the need of clearing the air. It has been predicted that by the year 2000, one-half of the energy production in the United States will be from atomic energy. Future engineering applications of nuclear technology with respect to large power reactors may well offer one solution to the avoidance of undesirable stack emissions.

Douglas Berry. I have a series of questions here directed to Ted Frankenberg. First, would you consider legislation to be realistic which established a limit of Ringelmann No. 2 or less for normal emission from pulverized field-fired thermoelectric generating plants of 1,000 to 3,000 megawatt capacity? Second, would other more modern and scientifically determinable standards, such as weight of dust emitted, be more appropriate for such plants? And third, would you consider the above limits realistic for oil or gas firing?

Frankenberg. As to the last question, I have no experience with oil and gas firing, but you got a fair sort of reply in Mr. Bishop's comments a few moments ago about oil and gas as compared with coal. The second question, about the desirability of a more scientific standard than the Ringelmann, gets an unqualified yes. As many of you know, work is going forward at the Taft Center in Cincinnati to develop a reasonable opacity meter. This is being American Society of Mechanical Engineers which got a lot of opposition 2 weeks ago at the annual meeting. Most of the opposition arose from the fact that a great many people feel that the Ringelmann chart, which was intended to measure densities of black smoke, is not a particularly good measure for all kinds of stack gas effluent. Very frequently stack discharges have other colors that do not give true readings when you use the Ringelmann chart. That particular ASME writeup made it sound as though the Ringelmann was quite the standard and I think that we are gradually going to have to work away from it into something more dependable. Most people who actually use Ringelmann realize that it's sort of an arbitrary thing. It has a lot of limitations, depending upon how you look at a plume—by reflected light, or on the other side with the light coming through the plume. The second part of your question was about how you handle this when you get 1,000 to 3,000 megawatt units. I think the thing to do is to get some other standards. I hope that the work going forward at the Taft Center gives us this sort of standards very shortly.

Sol Pincus. It might be of interest to know some of the history that led to the department which Mr. Benline heads in the city of New York. In 1935 the New York City Department of Health was doing very little in air pollution; in fact there was hardly any air pollution control then, other than answering complaints of smoke or odor. The health department obtained a considerable grant from the Government for a Works Progress Administration study of air pollution. About 200 persons worked on it. Fortunately, some were very highly skilled technical personnel, such as engineers, chemists, and bacteriologists. The study was under the direction of Mr. Arthur Stern, who is now Assistant Chief of the Division of Air Pollution, Public Health Service. The study showed a basic air pollution problem in New York City. After several years of work the project was suspended because the WPA funds expired and unfortunately, the economy-minded mayor didn't support any continuation. Probably the health department didn't push it hard because the Donora episode had not yet happened. Help was requested from the Fed-

eral Government, but it was unable to devote any funds to it. The Public Health Service effort at that time in the field of air pollution was practically zero; they had one man, a physicist, whose main work was to study light densities as affected by smoke in various places throughout the country. He visited cities for a while and reported on what happened when locomotives or local powerplants began operation. And reports of his work was all the help the Federal Government could give us. We visited cities that were doing some work in the field, such as Cleveland, Chicago, and Washington. Even this brief reference shows the status of work in air pollution at that time and we can realize what tremendous progress has been made since, and in a relatively short time. Another incident may also be of interest. About 1939 or 1940, when preparations began for World War II, the Federal Government placed a tremendous electrolytic aluminum plant in the heart of the city of New York. This plant put a tremendous overload on the Consolidated Edison generating plant at Hudson Avenue. Immediately, those of us in the health department and in the office of the mayor received numerous complaints, with people even bringing in cigar boxes full of soot and detritus. People were ready to march on City Hall, and we had to get busy and do something. The first thing we did was to call in officials of the power company, including the vice president and the chief mechanical engineer. They admitted that the situation was serious, but they didn't see what could be done. The plant had to be in operation and the overload came from the Federal Government aluminum plant.

We couldn't leave the situation as it stood, so we told them that we'd make an investigation before meeting with them again. Fortunately, we were able to get Mr. Stern, who was then with the New York State Labor Department, to spend about 3 weeks on an investigation. For the second meeting we presented about 25 suggestions to them, which rather startled them. One thing we asked was that they operate through auxiliary plants that were called "standby," but were never expected to be in operation again. We asked them to put on 24-hour repair crews wherever they had any trouble. We also asked them to ease the night load of the Hudson plant as far as they could by keeping other plants going. Another problem was that they wanted to improve the smoke control equipment but couldn't get any of the necessary material released by the War Production Board. Through our intercession with the Federal Government we were able to solve that problem and get them their materials in double-quick time, which improved the situation until the entire aluminum plant was closed. After that, it seemed that the city health department was not interested deeply in air pollution and they had the work turned over to the department of housing and buildings. It didn't get much attention there, either. But outside groups were interested in seeing that a new city department of air pollution should be inaugurated, and that's the department in which Mr. Benline is now doing such a remarkably efficient and creditable job. He shouldn't get discouraged, because there's been such a tremendous advance in the last few years.

John A. Rodda. In Mr. Frankenberg's paper and in Mr. Perry's comments, reference is made to the problem of sulfur-containing fuels and the possible removal of sulfur oxide from the combustion gases. Has investigation been made of chemical reactant methods utilizing low-cost chemicals which react with the sulfur oxides to form gaseous or precipitable solid products? If so, by whom and with what reactants and what results?

Perry. The work in this field started early in the 1930's and I believe Professor Johnston at the University of Illinois was the leader. The obvious solution to the problem was to wash the acidic gases with some form of cheap alkali in a liquid gaseous system, and the obvious choice was ammonia. Ammonia was cheap and plentiful and the product, ammonium sulfate, could be sold as a fertilizer.

This initial work was followed by further work in the 1950's in this country and in England. In the United States at that time, I believe the leader was the Tennessee Valley Authority, but a thorough examination of the economics of this solution was made in the late 1950's by the Bureau of Mines as a preliminary to additional research. The difficulty with the liquid gaseous system was that one has to cool the gases, which results in dispersion of the residual gas even if the sulfur dioxide (SO_2) is scrubbed from the start, a step which adds to the difficulty. There isn't enough energy to disperse the SO_2 over a wide area, so the pollution problem at the stack in the immediate vicinity of the plant can actually become worse, even though the process removes 90 percent of the SO_2 from the system. With this limitation, noted both in this country and in England, we decided to concentrate on solid absorbents which didn't need cooling. Before I leave the liquid scrubbing systems, among which the

the price of coal delivered at the plant could be as low as $4 a ton, the burden of adding another $1.50 a ton can be an excessive one.

We are now investigating solid absorbents which can be operated at higher temperatures. We are especially interested right now in the manganese oxide system, both in fixed beds and in foam beds.

In addition to the work of the U.S. Bureau of Mines, the English are investigating the problem of long exposures in solid absorbents, and the Germans have recently reported that they have found a way of doing this, using a cheap solid absorbent made out of coke or even chrome. We haven't had a chance to investigate these claims, but we are planning to send a man to Europe to find out if this method would be cheaper in the solid absorbent systems that we're studying. In addition to removing the sulfur dioxide from the gases, we are studying other methods in this country. Through the utility industry, the Edison Electric Institute has supported a research program. One of its projects is bituminous coal research with the object of removing the sulfur from the coal before it's fired into the boiler. The approach currently being used is to check the grind of coal and see whether or not sulfur compounds are present in larger percentages in a particular size fraction which could then be separated out. Other methods have been explored and are being explored. We are also trying to remove sulfur by the use of micro-organisms. In addition to this we have recently followed up a Russian discovery that oxidizing a coal slightly during its preparation will make it more magnetic, and the magnetic pyrite particles can subsequently be separated from the coal. We've had some very encouraging results and we are continuing to pursue this lead.

John F. Stephens. Commissioner Benline, the dry sand cleaning of brick homes occurring in residential districts creates grossly excessive dustiness, with the principal soiling on neighboring properties. The work is done on a somewhat fly-by-night basis and, since no warning is given, by the time the unsuspecting neighbor knows what is happening to him, the job is done. It takes normally 1 or 2 days. What can be done to preclude or otherwise intercept emission creation of this type?

of brick homes in New York City, where most commercial operations involve steam cleaning. Nevertheless, his original reply has been retained, because it provides useful information on air pollution from drycleaning establishments.]

Benline. We have had suggestions from many people to disregard pollution from drycleaning because it was nothing to worry about. We have found that it is a very considerable problem. In our attempts to establish adequate criteria, we had good information from Ottawa, excellent material from Michigan, some from West Virginia, and some from the Underwriters Laboratories. Our own New York City Board of Standards and Appeals has written basic regulations for drycleaning establishments. We believe they are inadequate with respect to the terminal event, the ultimate release of the pollution. Because of this, we have been developing new criteria. We have already sent out preliminary copies. We have been attacked very severely by people in the industry who say that they can do everything that has to be done, and that they don't need any regulations. But we've heard this cry before. Excellent regulatory material is available from the Michigan State Health Department. We are relying on material received from them, which we balance against other material on the same subject. For copies of our material, you can write our director of engineering, Leo P. Flood.

Sussman. I should like to comment on the three statements transmitted by Mr. Linsky from the Bay Area APCD and the County Supervisors Association of California. The first concerns congressional adoption of legislation for rapid tax writeoffs of correction equipment, air pollution control devices. This has been discussed considerably. It's recorded in the 1958 conference. There have been a number of proposals. We know of industries which feel that the present methods for obtaining tax writeoffs under certain regulations of the Internal Revenue Service are adequate. The second statement concerns whether or not the Federal Government should require as a condition for Federal financing of projects that such projects should fully conform to local air pollution control requirements. In Pennsylvania the highway department has cooperated with the Pennsylvania Air Pollution Com-

sion. This type of action at the Federal level could be quite effective. By an Executive order, the President has required that Federal installations comply with local ordinances. This point was discussed by Commissioner Benline in the last part of his presentation.

The third statement was that planning agencies and community planners should be educated with respect to air pollution problems. There is a definite need for revision of the lists of obnoxious industries which many zoning ordinances treat as hazards and nuisances per se. These lists are not up to date and should be revised. Many industries on these lists now have methods of control and, as pointed out by Dr. Faith, most industrial air pollution problems are susceptible to economic methods of control. The characterizing of certain industries as obnoxious or unwanted is obsolete and not consistent with effective and reasonable modern zoning procedures.

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I shall not attempt to comment specifically on the seven papers you have heard. Rather, I shall draw a few conclusions. Throughout our panel session and in the open discussion, the following themes were repeated. First, the sources of air pollution are numerous. Second, the problems of identification, measurement, effects, and control of pollutants range from simple to very complex. Third, economics is vitally important. Fourth, considerable progress has been made in the past decade, and further progress will continue to be made.

Panel C

HEALTH CONSIDERATIONS

Public Asks About

Chairman: WILLIAM S. SPICER, JR.

Co-Chairman: ROGER S. MITCHELL

Reporter: J. B. ASKEW

Participants

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AIR POLLUTION, MORBIDITY, AND MORTALITY

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Air pollution morbidity means sicknesses due to air pollution, and initial efforts at research on health effects of air pollution were concerned with questions such as how many cases of asthma, bronchitis, or emphysema, are caused by air pollution. Similar questions about deaths due to air pollution were raised. We have learned that the methods of study available and the chronic nature of the diseases combine to make these very difficult questions to answer. By population survey methods, however, we have learned that there are widespread health effects reported, which go beyond what are customarily included in morbidity rates, but in some respects are more meaningful.

The questions which the public is asking about air pollution health effects will be put in nontechnical terms and answers, when available, will be outlined.

Public Concern About the Health Effects of Air Pollution

Let us visit together the home of the average well-informed urban citizen. Shall we call this family, from the first initials of their name (Average Well-Informed Urban Citizen At Home) the Awiucah? Without naming the community in which the Awiucahs live, I ask you to imagine that they live in any community experiencing air pollution and troubled by it. On our visit, after identifying ourselves as being from an official agency charged with studying the effects of air pollution, we are cordially admitted. We ask the question, "Are you bothered by air pollution?"

"Yes, indeed," says Mr. Awiucah. "When I bought this house 10 years ago, this was one of the nicest residential districts in town, but since the new factories have been working full blast, the smoke and haze have kept us from seeing the mountains. The neighbor across the street just put his house up for sale so that he could move to a place which his doctor said would be healthier for him. The property values are declining because this isn't as nice a place to live as we had hoped it would be. If something isn't done about it, my family and I will have to give serious thought to moving as well."

It is now Mrs. Awiucah's turn. "Do you remember that bad hot spell we had a few weeks ago? It was so bad that my father died the day the weather cleared up. He had been in a nursing home and was moved to a hospital but, despite what the doctors did for him, his breathing got no better and he finally died. The smog is always worse during hot weather, but hot weather never used to bother our breathing. Our youngsters also suffer. One of the children has asthma, and when the smog is bad, he is worse. He missed 4 days of school during this bad smoggy period last month.

"Not only does it bother our health," Mrs. Awiucah continues, "but it adds to the housekeeping chores. I have to wash the windows and curtains three times as often now as I did 10 years ago, and it's not possible to hang the wash outside without the risk that it will be soiled by cinders or soot."

"It also," says Mr. Awiucah, "interferes with my hobby. I am an amateur orchid grower and since the new freeway went through three blocks from our place, I can't grow first-rate blooms any longer.

"This stuff must be harmful," he goes on; "it is so irritating I cannot drive my delivery truck through town on a bad day without my eyes smarting so that I cry enough to fill a bucket."

"Besides," says Mrs. Awiucah, lighting a cigarette and offering each of us one, "this dirty stuff in the air can cause lung cancer, can't it? I am worried about myself and my family."

Fortunately, there is no such family as the Awiucahs, and no such community has all of the problems which this family asks about.

ditions which were associated with low winds and stagnant air have led to mortality clearly beyond what would have been expected otherwise. In Belgium in 1930, in the Meuse River Valley (*1*), a large number of people had respiratory tract irritation and 60 died. The illness in each of these episodes affected mostly older persons with previously known diseases of the heart and lung.

In 1952, most of the British Isles were covered by fog and temperature inversion during the week of December 5 through 9 (*2*). An unusually large number of deaths occurred and many, many persons were ill. An increase of mortality at all ages was observed, but the greatest increase was in those in the 7th and 8th decades. The mortality remained elevated for several weeks after the weather had cleared. The total excess was between 3,500 and 4,000 deaths.

In 1948 (*3*), in the valley of the Monongahela River, Pa., the Donora episode caused 43 percent of the population to become ill and 20 died in a community of less than 15,000.

More recent episodes have been reported for New York (*4*) in November 1953 and for Los Angeles in August and September 1955 (*5*), but the number of excess deaths was small in the former episode and the effect of air pollution was complicated by extraordinary high temperature in the latter case.

Air Pollution as a Cause of Acute Sickness

Physicians as well as laymen have reported that asthma and other respiratory complaints are worse during smoggy weather. In one study in Los Angeles, a record was made of the occurrence of asthma attacks in a group of asthmatic patients in 1956 (*6*). These were compared with air pollution measurements, pollen counts, and determinations of temperature and smog damage to vegetation. No environmental factor could be found to precipitate the great majority of asthma atacks; however, there was a slight statistical association between the onset of attacks and typical smog damage to vegetation. The association could have occurred if about 7 percent of the asthmatics were in fact reacting to air pollution.

Possible relationship between air pollution and asthma attacks has also been recorded from New Orleans (*7*) and from the Kanto plains area in Japan (*8*), where American servicemen have experienced much disability as a result of air pollution tionship of air pollution in Nashville, Tenn., to asthma has also been reported by a team from the Public Health Service (*9*).

Air Pollution and Chronic Disease

Studies of chronic disease rates in Great Britain in relationship to air pollutant levels have demonstrated that there is an impressive relationship between morbidity and mortality rates from chronic bronchitis and air pollution (*10*), on the one hand, and mortality from lung cancer and air pollution on the other (*11*). In the United States the evidence is not as clear cut. The rates for chronic bronchitis and lung cancer are in general lower in the United States than in Great Britain, when comparable age and sex groups are compared. However, both of these groups of conditions are more common in urban than in rural areas, and air pollution has been thought of as the possible factor to account for these increases (*12*). On the other hand, clear-cut relationships of cigarette smoking to both of these conditions have been established in this country as well as Great Britain (*13, 14*). Because different patterns of decisions are needed for reducing the exposures, we may tend to separate the effects of cigarette smoking on chronic lung disease from those of community air pollution on the same condition, but it is not reasonable to expect that the cells of the lung will make such a distinction. For this reason it is our current view that the total amount of inhaled pollution, regardless of the source, is probably a single one of the factors which influence the rate of both lung cancer and chronic nontuberculous lung diseases. Attention must be directed to at least three major types of exposure: occupational air pollution, community air pollution, and the air pollution associated with the smoking of cigarettes.

From both experimental and epidemiologic studies, there is every reason to think that some individuals are more sensitive to air pollution than others. We know, for example, that some individuals are unusually sensitive to small amounts of sulfur dioxide (*15*). In all likelihood, therefore, it will some day be possible to determine which individuals are most susceptible to inhaled pollutants and to direct our preventive efforts to these individuals.

A number of studies have investigated how much aggravation of a preexisting lung condition could

subjects (*16*). The disadvantage of such studies is that the quite severely ill persons fluctuate in their state of health rather widely even in the absence of air pollutants or other detectable causes. It has been clearly shown by Motley, Leftwich, and Smart (*17*) that men with severe emphysema, placed in rooms from which smog was filtered, had improved lung function when this procedure was followed during smoggy weather. When they were placed in the same rooms during weather in which the smog levels were low, there was no improvement. There was no improvement detected in persons without emphysema placed in the same rooms during smoggy periods. From this it is suggested that air pollution had produced some decrease in the function of lungs in emphysematous persons.

Interference by Air Pollution With Important Functions of the Body

Two functions have been examined with some care. The ability of lungs to move air in and out has been studied by making measurements of the resistance to airflow within the conducting passages of the lung (*18*). Very sensitive and reliable instruments have been developed in the past few years which make it possible to measure changes in the resistance to airflow of which the subjects themselves are unaware. Increases in the airflow resistance increase the amount of work which must be expended in order to breathe (*19*). Low concentrations of sulfur dioxide, inert dusts in fairly substantial doses (*20*), and the smoke from a single cigarette (*21*) have all been shown to produce increases in the resistance to airflow. Relatively little use has been made of these sensitive methods in investigating community air pollution, though other methods have been used to measure lung function in a variety of field studies. The results of most of these studies are inconclusive. However, the studies of Motley et al. do suggest that in some circumstances such an effect could be found.

A second major function with which air pollution interferes is the transport of oxygen by hemoglobin, the red pigment of the blood. This function is interfered with by relatively small concentrations of carbon monoxide (*22*). For example, it has been estimated that continued exposure to 30 parts per million of carbon monoxide would tie up about 5 percent of the body's circulating hemoglobin, making it unavailable for the transport. While most people would be completely unaffected by such a small change in the oxygen capacity of the blood, certain individuals with borderline effectiveness of the heart, lungs, or blood vessels may be affected in an important way.

Irritation of the Eyes, Nose, and Throat

The most widespread effect of smog in Los Angeles is eye irritation with tearing and redness (*23*). The exact substance responsible for this is not known, but it is known that it can be reproduced by mixtures of hydrocarbon vapors and oxides of nitrogen which are irradiated by strong lights or by sunlight. Almost 75 percent of the population in Los Angeles County is thus bothered by air pollution. Studies so far fail to indicate that any chronic or long-term effects can be attributed to this irritation. In addition, a number of people report that smog in Los Angeles interferes with their breathing and produces throat irritation. In other parts of the country, flyash is a distressing pollutant, in part because the particles get into the eye. Also sulfur dioxide is a respiratory tract irritant. But even in London, where sulfur dioxide and flyash pollution is supposed to be much greater than in urban areas of the United States, there is nothing like the widespread symptoms that occur in Los Angeles from photochemical air pollution.

Many air pollutants have a distasteful odor. Among the worst is hydrogen sulfide, which can be detected by its unpleasant odor at a concentration of one-tenth of a part per million. Ozone also has an unpleasant and irritating odor but is capable in addition of paralyzing the sense of smell (*24*).

Interference With Human Well-Being

Obliteration of the view, obscuring of the sun, and damage to home or commercial garden plants, may not usually be thought of as effects of air pollution on health. But they do interfere with the enjoyment of living. When air pollutants are capable of soiling paint, windows, and fabrics, and harming vegetation, the importance to human well-being may not be safely overlooked.

Summary

"Air pollution morbidity and mortality" means the measurable effects of air pollution on human health and well-being. These effects are measured by the collected experience of many urban families.

measured in the disasters of London, Donora, and the Meuse Valley.

2. The causation of acute illness, primarily asthma and other respiratory conditions which have been detected in New Orleans, Tokyo, Yokohama, and possibly Pasadena.

3. Occurrence of chronic lung disease such as chronic bronchitis, emphysema, and cancer of the lung which have been related to air pollution in England. While there is an excess

4. Interference with important functions of the body, particularly the function of moving air into and out of the lungs, and the transport of oxygen by the hemoglobin of the blood.

5. Irritation of the eyes, nose, and throat.

6. Impairment of well-being because of interference with view, of property damage, of damage to vegetation, and of interference with the enjoyment of living.

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Prepared Discussion: AIR POLLUTION, MORBIDITY, AND MORTALITY

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The objective and realistic conclusions presented by Dr. Goldsmith, in relating what reasonably can be accepted thus far from an examination of morbidity and mortality data associated with air pollution, emphasize the complexity and the difficulty of the problem, and the long road ahead. The increases in illness and death in the three incidents or accidents—the Meuse Valley, Donora, and London—serve as a traditional point of departure in every major discussion of the health considerations in air pollution, but are of limited practical value in assessing the diffuse and varied air pollution problems which face our American cities. Similarly, the episodes in Japan and in New Orleans, while connoting that under special circumstances epidemic asthmalike disease is associated with air pollution, contribute very little to the appraisal of the general problem. In the former examples, at least with respect to the Meuse Valley and Donora, the control of industrial plant effluents during periods of severe inversion will at least prevent a major incident. The asthmalike characteristic of the illness in the Kanto plains in Japan suggests a peculiar etiologic factor, or factors, which may bear little relation to the conditions affecting people with asthma in the varieties of air pollution reported in this country. These incidents clearly signal that specific types of pollution above a certain level can and do seriously affect health, but offer little help in extrapolating downward to lower levels of exposure and more chronic effects, which is our major problem.

At the other end of the scale, in measuring the health effects of air pollution, are the damage to vegetation and to property, and in certain situations the marked irritation of eyes, nose, and throat. The annoyance and frustration value of these characteristics should not be underestimated, but there is no good evidence that they are in themselves indicators of serious pathological conditions. Fortunately, the discomfort factor often serves as a more powerful stimulus to public action than the threat of a more serious but more remote and less readily appreciated effect, such as lung cancer.

The substantial evidence needed to define the effects on health from air pollution must come from broad epidemiologic studies of morbidity and mortality, from realistic and valid experimental toxicology, and from clinical studies contrived to demonstrate meaningful effects from the varied environmental factors encountered in actual air pollution conditions. The interpretation of the results of investigations in any one of these areas frequently is difficult; the synthesis of information from all of the approaches, in terms that are sufficiently convincing to generate acceptance and effective action by the public, will tax the ingenuity and the ability of all of us in environmental health.

I would agree with the inference of Dr. Goldsmith's conclusions, that much more epidemiologic evidence is needed to define the relationship of air pollution in this country to such effects as chronic bronchitis and pulmonary cancer. Similarly, although a beginning has been made in evaluating the factors in air pollution with clinical changes, the surface scarcely has been scratched in this important investigative approach. To the moment, the evidence thus far accumulated demands of the prudent observer that further and better information be acquired.

There are important analogies for the study of the health effects of air pollution from the experi-

safe and healthful for a wide variety of hazardous chemical and physical agents has been a slow and laborious process. Here, in many instances, we were dealing with a single substance, with an exposure relatively easily characterized qualitatively and quantitatively, with an exposed population which usually could be thoroughly evaluated—and frequently with instances of overt occupational disease clearly identifiied with higher exposure conditions. The extrapolation downward to safe levels for short-term exposure has been relatively easy. But, among the some 300 threshold limit values now accepted and applied in industry there are probably less than 10 with adequate documentation to justify their acceptance, if the true and rigid criterion were that of a safe and healthful environment over a full working lifetime. In spite of this deficiency, these threshold limit values serve a very useful purpose, and in the judgment of the majority of experienced observers, provide a good approximation to the longer term criterion.

levels of radiation have been progressively reduced and as the end points of effect have been extended to include carcinogenesis, shortening of life span, and genetic changes, the technological complexities and the cost of meaningful studies have gone up in geometric proportion. We have progressed in our scientific jargon from such terms as "a million fruitflies" to "mega-mouse" and "mega-buck"—the latter meaning dollars rather than male deer. When, however, we attempt to study these smaller effects in man, a point is reached at which the identification of the component specific to radiation, in relation to all of the other variables to which our population is subject, becomes an almost impossible task. We have not reached this "diminishing return" effect in the study of air pollution but, as in the case of radiation, it is probable that we shall have to make important and far-reaching value judgments before we have acquired the human morbidity and mortality data which would in itself carry general conviction.

THE COMPLEXITY OF THE RELATIONSHIP BETWEEN AIR POLLUTION AND RESPIRATORY HEALTH

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That the relationship between air pollution and respiratory health is complex is obvious to the many who are attempting to evaluate it. A listing of the various known and probable factors involved, with the combinations and permutations possible, would adequately, but tediously, fill the allotted time. As the purpose of this conference is the presentation of the present status of our knowledge, we will sacrifice such completeness of listing in order to attempt to illustrate our level of understanding (or lack of understanding) of the complexities involved even in demonstrating this relationship.

Respiratory health, in itself, is not a simple concept and has different meanings for different investigators. The recording of the symptoms of chronic bronchitis, e.g., cough, sputum, wheeze, breathlessness, etc., in a control population in relation to either daily or long-term levels of air pollutants differs from the recognition that individuals who have no clinical symptoms change in relation to environmental factors when tested by complex pulmonary function tests. The determination of the prevalence of acute respiratory infections or of carcinoma of the lung, the observation of disaster episodes or the tentative establishment of community air quality standards, which may be done in relation to air pollutant levels, differ from both of the former in interpretation. Certainly, all of these valuable approaches should and do complement each other. But, just as certainly, they can not be equated. Utter confusion and misinterpretation will result unless we are constantly clear as to which particular aspect of respiratory health is being evaluated in any particular investigation.

Let us proceed step by step through a specific investigation. The primary purpose of this study is to determine whether there is a cause-and-effect relationship between environmental changes and the changes occurring in the respiratory status of a group of human beings living in a residential area in the center of an urban community. While the individuals undergo daily clinical and bacteriological evaluations, the primary tool utilized in assessing their respiratory status is a daily battery of objective pulmonary function tests.

For orientation, we are discussing a 20- by 40-block residential area, topographically low and flat, with a population of some 200,000 residing in row houses, 40 percent of which are heated by coal, kerosene, or wood burning stoves. The predominant winds over this area are either from the northwest or the southwest. To the southwest lies a major industrial complex; to the northwest, suburban residential and farming areas. The average yearly suspended particulate from urban stations is 130 micrograms per cubic meter. This would place the area as an "average dirty" community.

The clinical pulmonary physiologist often thinks of the average human being as a lung which is intermittently flushed by the air of the surrounding environment through a connecting tube, or airway, as illustrated in figure 1. At the top of the diagram we have illustrated the lung and airway of a normal human being. At the top left this individual has filled his lung to its fullest extent with ambient air. The airway is thin, elongated, and distended. The cross section of the airway is shown at the top in each case. The maximum amount of gas that an individual's lung may contain is called the Total

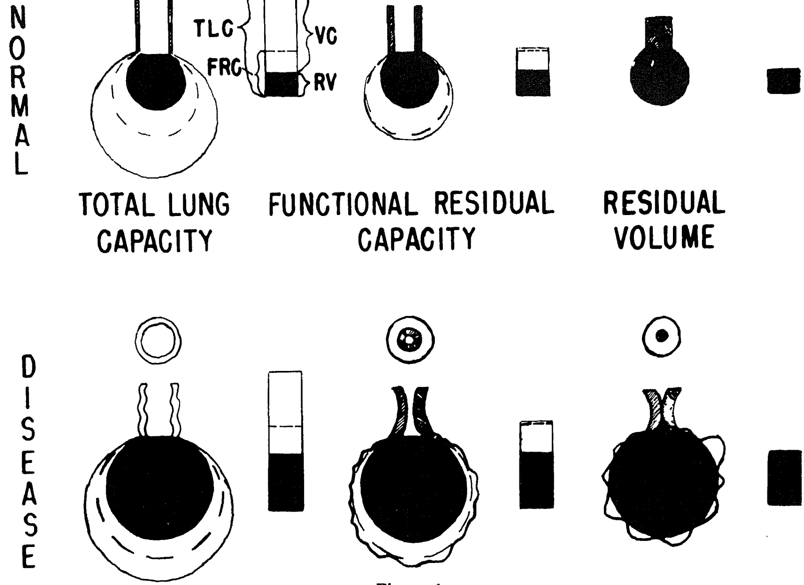

Figure 1

Lung Capacity. The clear area represents the amount of gas which he can expel from his lung, and is called the Vital Capacity. The gray area is the volume of gas remaining after he has exerted a maximal expiratory effort, and is named the Residual Volume. The dotted line is the volume of gas in his lung at the end of a normal respiration. This volume point is determined by the ease with which gas can pass through his airway, or the Airway Resistance, and the ease with which his lungs can collapse, and is known as the Functional Residual Capacity (FRC). In the middle illustration the normal individual has let air out of his lung to the normal resting respiratory position. His airway is shortened and its diameter narrowed. At this point the airway still does not present excessive resistance to the flow of gas. Expiring from full inspiration to full expiration is done easily until the FRC is passed, at which time it becomes increasingly difficult to collapse the lung and force the gas through an airway which is shortening and decreasing in size. Finally, the airway closes completely and expiration stops. During the late stages of expiration, airway resistance increases rapidly and considerably, secondary to the decrease in airway size.

The bottom half of the diagram represents the disease state. It is applicable to an individual who has either permanent or transient pulmonary disease.

Diagrammatically, we can summarize the effect of inhaled irritants upon the airway as leading to inflammation, with thickening of the wall and a resultant decrease in the diameter of the lumen. The airway widens and elongates with inspiration and shortens and narrows with expiration. Thickening of the wall will affect particularly the Expiratory Airway Resistance. This, in turn, will affect

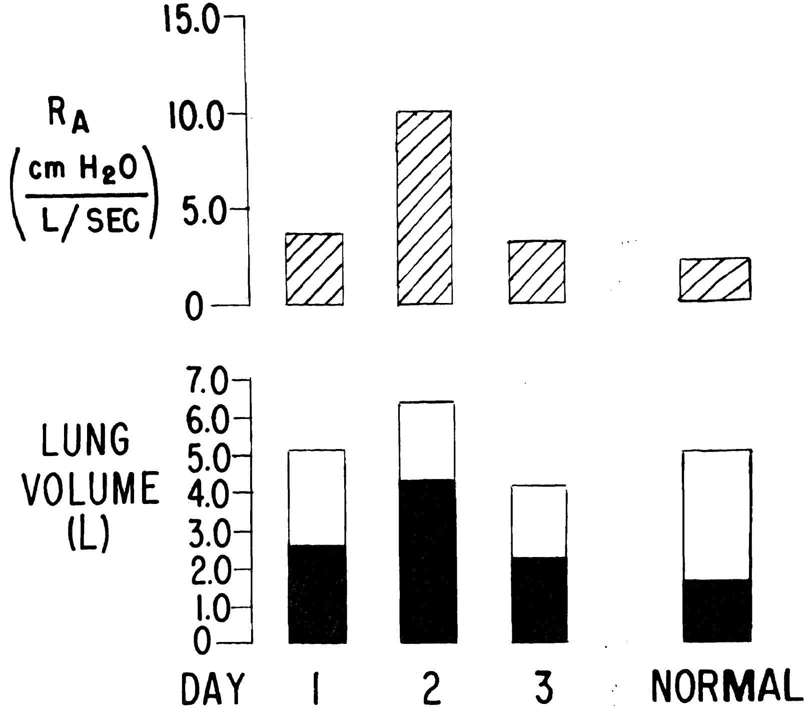

Figure 2

the lung volumes. Firstly, the airway will close earlier, increasing the Residual Volume. Secondly, the individual will breathe at a higher level in order to avoid the work of breathing out against the increased airway resistance at the lower volumes. Thirdly, the lung will be stretched more at full inspiration in order to build up more elastic recoil to aid in expelling gas through the narrowed airway. If, in addition, the individual has permanent lung damage, the lung tissues will have lost elasticity and the airways will tend to collapse.

At the lower left the diseased lung is at full inspiration. The Total Lung Capacity is increased. As the individual expires fully the airways, which are already smaller than normal, close at an earlier point and also have a tendency to collapse. The result is that the residual volume, or the amount of gas remaining in the lung at the end of a full expiration, is considerably increased. In addition, the lung tissue itself is diseased and on expiration portions of it fail to collapse smoothly, as is illustrated in the diagram by the wavy appearance of the lung volume. Adjacent to each of the circular diagrams is a block diagram of the lung volumes, which may be used for graphic comparisons with air pollutant levels. In summary, one way in which either the normal or diseased lung responds to inhaled irritants is by an increase in expiratory airway resistance, often accompanied by an increase in the lung volumes noted.

Now that we are prepared as pulmonary physiologists it would be well to immediately share in

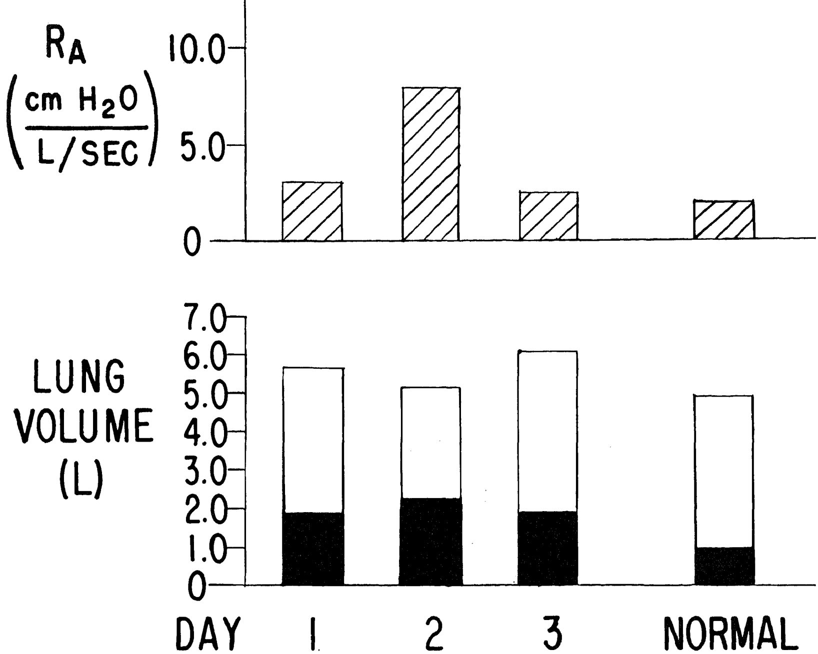

Figure 3

the difficulties encountered in measuring human beings. One of the first problems which we must face is the meaning of objective pulmonary function measurements. The physician is often inclined to feel, once he has made a measurement of a subject, that one measurement is valid for the individual over some period of time.

In figure 2 we have illustrated the airway resistance and lung volumes obtained on one patient on three consecutive days. Note immediately the vast amount of the change in the pulmonary function tests in this relatively short period of time. For comparison his predicted normal values are seen on the right. On day 2 the patient has become obviously and grossly abnormal. However, in an additional 24 hours his pulmonary function tests have changed strikingly, with his total lung capacity having decreased by better than 2 liters. His studies now are borderline normal and, without objective pulmonary function tests, he might be judged normal. Consider our dilemma when faced with the problem of evaluating a large population group by a questionnaire and relatively simple pulmonary function tests, if, over the period of days or weeks which it will take to evaluate the group, their pulmonary function is changing to these extremes.

In figure 3 the studies of a second patient for the same three-day period are shown. As with the previous patient there is a sharp rise in airway

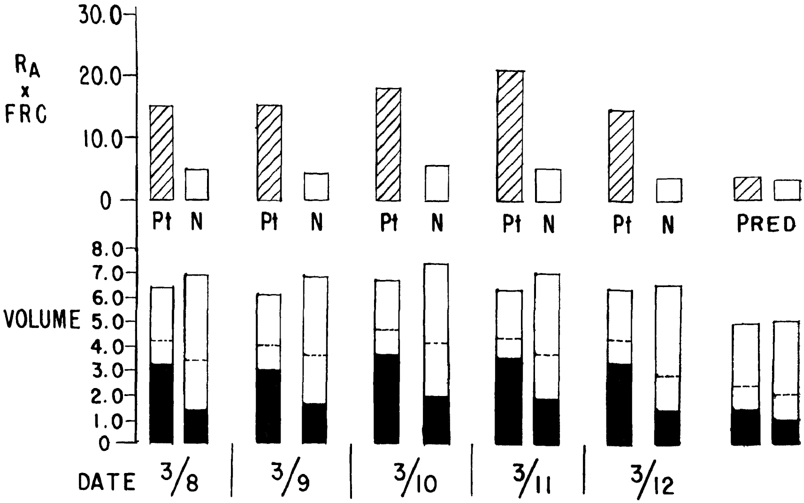

Figure 4

resistance on day 2 and a fall on day 3. However, the changes in the lung volumes differ considerably, with a fall in the total lung capacity on day 2. Both of these patients appear to be similar clinically. However, their physiological reaction differs. Thus, similarity of clinical symptoms of disease does not mean physiological similarity.

Now let us go more directly to the problem of groups of patients in relation to environmental change.

In figure 4 are shown the mean daily airway resistance and lung volume of a group of patients (at the left) versus 11 normal young people between the ages of 19 and 28 years (at the right). Examining the record of patients, you see a definite increase in the mean values of airway resistance, reaching a peak on the 11th of March. An earlier peak of change in lung volume is obtained for the patients by the 10th of March, with an increase in residual volume and total lung capacity. More surprisingly, the mean changes in the normals mimic the patient changes. There is an increase in airway resistance, but, more strikingly, there is a significant increase in the mean residual volume and total lung capacity of the normal group, followed by a decrease as the airway resistance returns toward normal.

This is not an isolated finding. In fact, the demonstration that patients with chronic lung disease and normals change together over extended periods of day-to-day study must lead one to the conclusion that they are reacting to something common in their common environment. In itself, it is significant and exciting. However, much of our enthusiasm must be tempered when we begin to consider some of the possible explanations. First, we must be cautious in suggesting an etiologic relation. We must not jump to the conclusion that these normals will eventually progress to abnormalcy because their reaction is similar to that of the patients. To be precise we have simply shown an ability of patients and normal individuals to react to some presumably common factors without having shown definite evidence that these factors eventually will cause respiratory disease. Second, the term "common environmental factors" is remarkably obscure, as we do not know whether we are talking about factors in their external or community environment, factors in their homes, meteorological factors, air pollutant factors, or others. Therefore our next step must be to compare the

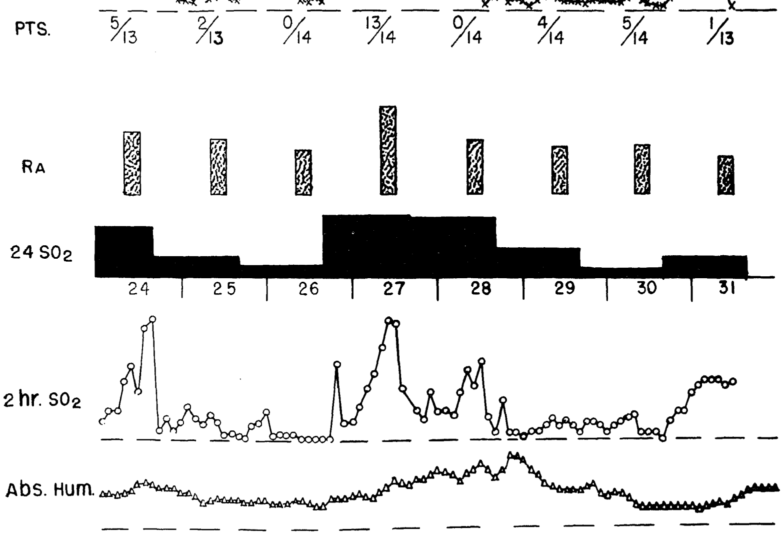

Figure 5

physiological changes exhibited from day to day and to try to correlate these with changes in environmental factors.

In the center of figure 5 we have shown the mean airway resistance of 14 patients, time oriented on a daily basis. Above airway resistance is the ratio of patients worse to patients studied. Above this are two-hour spot samples and below it are 24-hour SO_2 (sulfur dioxide), 2-hour SO_2, and absolute humidity values. With these few measurements it is now possible graphically to show some indication as to the relationship between the pulmonary function tests, as exemplified by airway resistance, and air pollutants or meteorological changes. One is immediately impressed with the rise in airway resistance and in the air pollutant factors on the 27th. Almost all of the patients became worse at this time. However, again our enthusiasm is tempered when we note that on the 28th all of the patients become better in spite of the fact that the pollutant levels show a second peak. We must now ask such pertinent questions as these: "Are the patients responding to peak levels?" "Are they responding to some sustained level?" "Does the increase in absolute humidity which occurs on the 28th mean that there has been clumping of pollutants, resulting in the formation of larger particles which fall out on the samplers but offer cleaner air to the patients?" "Are the patients responding to the levels which exist at the time of their examination or are they responding to levels at some previous time?"

My immediate reaction to figure 6 is that it is simply too much. On each study day some 1,200 individual measurements of patients, air pollutants, or weather conditions are made. Only a few of these are plotted on this graph. Beginning at the bottom, the mean airway resistance of the group is shown. This represents only one of a group of pulmonary function tests which were performed daily. We cannot be sure that this particular test is necessarily the best one to relate patient change to environmental change. Above this are excerpts

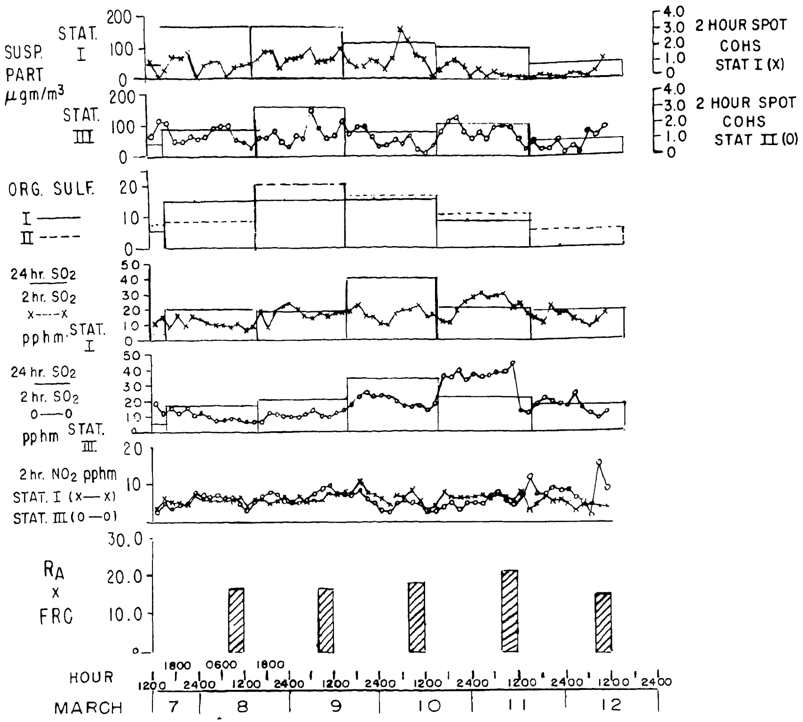

Figure 6

of the air pollutant data taken from only two of the five sampling stations in the area. The sampling stations shown are one mile apart and it becomes immediately apparent that in many instances they do not show a correlation. Therefore, we must consider relating our patients as to location to a sampling station. Next, the 24-hour levels are important if a sustained level of a pollutant is important to the patient reaction. On the other hand, they may give an entirely erroneous impression should the peak levels be the significant points for patient response. Certain of the pollutants at the two stations compare favorably. Others do not. There is a discrepancy between the organic sulfate levels and those of 24-hour SO_2. In which component are we most interested? Finally, the stimulus to the patient, if it comes from the community air, must probably be the result of a combination of weather conditions and air pollutants. Who can decide from this chart or put together, even on a limited scale, the possible combinations of various pollutants in all of the instances, allow for all of the possible time interval lags, and still make a reasonable evaluation?

We have arrived at the point where the human mind can no longer do graphic analysis of this situation and we must turn to a large computer manned by a highly competent programer.

Multiple regression correlation coefficients were obtained by comparing each pulmonary function measurement, in each patient, with a number of environmental factors. In table 1 the ...

Temp	—	—	—	—	—	—	—	—	—	—	—	—
Wind Speed	—	—	—	—	—	—	—	—	—	—	—	—
Rel. Hum	—	—	—	—	—	—	—	—	—	—	—	—
SO_2	—	—	—	—	—	—	—	—	+	—	—	—
NO_2	+	+	—	—	—	—	—	—	—	—	—	—
Spot	—	—	—	—	—	—	—	—	—	—	—	—
Stab. and W.S	—	—	—	—	—	—	—	—	—	—	—	—
Stab. and SO_2	—	—	—	—	—	—	—	—	+	—	—	—
Stab. and NO_2	+	+	+	—	+	—	—	—	—	—	—	—
Stab. and Spot	—	—	—	—	+	—	—	—	—	—	—	—
Temp. and R.H	—	—	—	—	—	—	—	—	—	—	—	—
Temp. and SO_2	—	—	—	—	—	—	—	—	+	—	—	—
Temp. and NO_2	+	+	—	—	—	—	—	—	—	—	—	—
Temp. and Spot	—	—	—	—	—	—	—	—	—	—	—	—
W.S. and SO_2	—	—	—	—	—	—	—	—	+	—	—	—
W.S. and NO_2	+	+	—	—	—	—	—	—	—	—	—	—
W.S. and Spot	—	—	—	—	—	—	—	—	—	—	—	—
R.H. and SO_2	—	—	—	—	—	—	—	—	+	—	—	—
R.H. and NO_2	+	+	—	—	—	—	—	—	—	—	—	—
R.H. and Spot	—	—	—	—	—	—	—	—	—	—	—	—
SO_2 and NO_2	+	+	—	—	—	—	—	+	+	—	—	—
SO_2 and Spot	—	—	—	—	—	—	—	—	+	—	—	—
NO_2 and Spot	+	+	—	—	+	—	—	—	—	—	—	—
SO_2 and NO_2 and Spot	+	+	—	—	+	—	+	+	+	+	—	—
Stab. and SO_2 and NO_2	+	+	+	—	+	—	—	+	+	—	—	—
Stab. and SO_2 and Spot	—	—	—	—	+	—	—	—	+	+	—	—
Stab. and NO_2 and Spot	+	+	+	—	+	—	—	—	—	—	—	—
Temp. and SO_2 and NO_2	+	+	—	—	—	—	—	+	+	—	—	—
Temp. and SO_2 and Spot	—	—	—	—	—	—	—	—	+	+	+	—
Temp. and NO_2 and Spot	+	+	—	—	+	—	—	—	—	—	+	—
W.S. and SO_2 and NO_2	+	+	—	—	—	—	—	+	+	—	—	—
W.S. and SO_2 and Spot	—	—	—	—	—	—	—	—	+	—	—	—
W.S. and NO_2 and Spot	+	+	—	—	+	—	—	—	—	—	—	—
R.H. and SO_2 and NO_2	+	+	—	—	—	—	—	+	+	—	—	—
R.H. and SO_2 and Spot	—	—	—	—	—	—	—	—	+	—	—	—
R.H. and NO_2 and Spot	+	+	—	+	+	—	—	—	—	—	—	—
Stab. SO_2 No_2 Spot	+	+	+	—	+	—	+	+	+	+	—	—
Temp. SO_2 NO_2 Spot	+	+	—	—	+	—	+	+	+	+	+	—
W.S. SO_2 NO_2 Spot	+	+	—	—	+	—	+	+	+	+	—	—
R.H. SO_2 NO_2 Spot	+	+	—	—	+	—	+	+	+	+	—	—

sistance of one patient has been compared with seven two-hourly environmental factors, first singly and then in various combinations. A correlation coefficient is obtained for each 2-hourly period of the day, beginning 24 hours prior to the determination of airway resistance and marching forward until the time that the patient is in the laboratory. In this manner, the possibility that the pulmonary function response is due to prior environment insults, and the time interval stimulus and response, can be evaluated. A plus sign indicates a significant correlation at the less than 1 percent level. For example, we see that a significant correlation is present when the airway resistances of this patient are compared with the nitrogen dioxide measurements of the day before between approximately ten in the morning and two in the afternoon. Throughout the chart, wherever nitrogen dioxide is present the correlations are significant. Other factors may become additive at other hours, but essentially, this patient reacts to the nitrogen dioxide levels present in his environment some 24 hours prior to his study in the

Hour	10–12	12–14	14–16	16–18	18–20	20–22	22–24	24–02	02–04	04–06	06–08	08–10
Stability	−	−	−	+	+	−	−	−	−	−	−	−
Temp	−	−	−	−	−	−	−	−	−	−	−	−
Wind Speed	−	−	+	+	−	−	−	−	−	−	−	−
Rel. Hum	−	−	+	+	+	−	−	−	−	−	−	−
SO_2	−	−	+	+	+	−	+	+	+	−	−	−
NO_2	−	+	+	+	−	+	−	−	−	−	−	−
Spot	−	+	+	+	−	+	−	−	−	−	−	−
Stab. and W.S	−	−	+	+	+	−	+	−	−	−	−	−
Stab. and SO_2	−	−	+	+	+	−	+	+	+	−	−	−
Stab. and NO_2	−	+	+	+	+	+	−	−	−	−	−	−
Stab. and Spot	−	+	+	+	+	+	+	+	−	+	−	+
Temp. and R.H	−	−	+	+	+	−	−	−	−	−	−	−
Temp. and SO_2	−	−	+	+	+	−	+	+	+	−	−	−
Temp. and NO_2	−	+	+	+	−	+	−	−	−	−	−	−
Temp. and Spot	−	+	+	+	−	+	−	−	−	+	−	−
W.S. and SO_2	−	−	+	+	+	−	+	+	+	−	−	−
W.S. and NO_2	−	+	+	+	−	+	−	−	−	−	−	−
W.S. and Spot	−	+	+	+	−	+	+	−	−	+	−	−
R.H. and SO_2	−	+	+	+	+	−	+	+	+	−	−	−
R.H. and NO_2	−	+	+	+	+	+	−	−	−	−	−	−
R.H. and Spot	−	+	+	+	+	+	−	+	−	+	−	−
SO_2 and NO_2	−	+	+	+	+	+	+	+	+	−	−	−
SO_2 and Spot	−	+	+	+	+	−	+	+	+	−	−	−
NO_2 and Spot	−	+	+	+	+	+	−	−	−	−	−	−
SO_2 and NO_2 and Spot	−	+	+	+	+	+	+	+	+	+	−	−
Stab. and SO_2 and NO_2	−	+	+	+	+	+	+	+	+	−	−	−
Stab. and SO_2 and Spot	−	+	+	+	+	+	+	+	+	+	−	+
Stab. and NO_2 and Spot	−	+	+	+	+	+	+	+	−	−	−	+
Temp. and SO_2 and NO_2	−	+	+	+	+	+	+	+	+	−	−	−
Temp. and SO_2 and Spot	−	+	+	+	+	−	+	+	+	+	−	−
Temp. and NO_2 and Spot	−	+	+	+	+	+	−	+	−	−	−	−
W.S. and SO_2 and NO_2	−	+	+	+	+	+	+	+	+	−	−	−
W.S. and SO_2 and Spot	−	+	+	+	+	+	+	+	+	+	−	−
W.S. and NO_2 and Spot	−	+	+	+	+	+	+	+	−	+	−	+
R.H. and SO_2 and NO_2	−	+	+	+	+	+	+	+	+	−	−	−
R.H. and SO_2 and Spot	−	+	+	+	+	+	+	+	+	+	−	−
R.H. and NO_2 and Spot	−	+	+	+	+	+	−	+	−	+	−	+
Stab. SO_2 NO_2 Spot	−	+	+	+	+	+	+	+	+	+	−	+
Temp. SO_2 NO_2 Spot	−	+	+	+	+	+	+	+	+	+	−	−
W.S. SO_2 NO_2 Spot	−	+	+	+	+	+	+	+	+	+	−	−
R.H. SO_2 NO_2 Spot	−	+	+	+	+	+	+	+	+	+	−	−

laboratory. He is apparently reacting to levels of short duration.

The results for the patient in table 2 are considerably more complicated. He appears to be reacting to a number of single and/or combined meteorological and pollutant factors. Although not shown in this table, the correlation coefficients increase when these factors are combined to the less than 0.001 level. This might suggest reactions to a sustained level and a combination of pollutants.

The third individual shown in table 3 reacts with a negative correlation to temperature on the afternoon and evening of the day before. Although the correlations do become higher with the addition of some other factors, in essence this patient is reacting to cold.

In summary, the research we have done today is based on actual studies. It represents one way of evaluating the relationship between air pollution and respiratory health. However, the results we have obtained have direct application to other methods of study now in use. With each step

Temp	—	+	+	+	+	—	—	—	+	—	—	—
Wind Speed	—	—	—	—	—	—	—	—	—	—	—	—
Rel. Hum	—	—	—	—	—	—	—	—	—	—	—	—
SO_2	—	—	—	—	—	—	—	—	—	—	—	—
NO_2	—	—	—	—	—	—	—	—	—	—	—	—
Spot	—	—	—	—	—	—	—	—	—	—	—	—
Stab. and W.S	—	—	—	—	—	—	—	—	—	+	—	—
Stab. and SO_2	—	—	—	—	—	—	—	—	—	—	—	—
Stab. and NO_2	—	—	—	—	—	—	—	—	—	—	—	—
Stab. and Spot	—	—	—	—	—	+	—	—	—	+	—	—
Temp. and R.H	—	+	+	+	+	+	—	—	+	—	—	—
Temp. and SO_2	—	+	+	+	+	—	—	—	+	—	—	—
Temp. and NO_2	—	+	+	+	+	—	—	—	+	—	—	—
Temp. and Spot	—	+	+	+	+	—	—	—	+	—	—	—
W.S. and SO_2	—	—	—	—	—	—	—	—	—	—	—	—
W.S. and NO_2	—	—	—	—	—	—	—	—	—	—	—	—
W.S. and Spot	—	—	—	—	—	—	—	—	—	—	—	—
R.H. and SO_2	—	—	—	—	—	—	—	—	—	—	—	—
R.H. and NO_2	—	—	—	—	—	—	—	—	—	—	—	—
R.H. and Spot	—	—	—	—	—	—	—	—	—	—	—	—
SO_2 and NO_2	—	—	—	—	—	—	—	—	—	—	—	—
SO_2 and Spot	—	—	—	—	—	—	—	—	—	—	—	—
NO_2 and Spot	—	—	—	—	—	—	—	—	—	—	—	—
SO_2 and NO_2 and Spot	—	—	—	—	—	—	—	—	—	—	—	—
Stab. and SO_2 and NO_2	—	—	—	—	—	—	—	—	—	—	—	—
Stab. SO_2 and Spot	—	—	—	—	—	—	—	—	—	—	—	—
Stab. and NO_2 and Spot	—	—	—	—	—	+	—	—	—	+	—	—
Temp. and SO_2 and NO_2	—	+	+	+	+	—	—	—	+	—	—	—
Temp. and SO_2 and Spot	—	+	+	+	+	—	—	—	+	—	—	—
Temp. and NO_2 and Spot	—	+	+	+	+	—	—	—	+	—	+	—
W.S. and SO_2 and NO_2	—	—	—	—	—	—	—	—	—	—	—	—
W.S. and SO_2 and Spot	—	—	—	—	—	—	—	—	—	—	—	—
W.S. and NO_2 and Spot	+	—	—	—	—	—	—	—	—	—	—	—
R.H. and SO_2 and NO_2	—	—	—	—	—	—	—	—	—	—	—	—
R.H. and SO_2 and Spot	—	—	+	—	—	—	—	—	—	—	—	—
R.H. and NO_2 and Spot	—	—	—	—	—	—	—	—	—	—	—	—
Stab. SO_2 NO_2 Spot	—	—	—	—	—	—	—	—	—	—	—	—
Temp. SO_2 NO_2 Spot	—	+	+	+	+	—	—	—	+	—	+	+
W.S. SO_2 NO_2 Spot	+	—	—	—	—	—	—	—	—	—	—	—
R.H. SO_2 NO_2 Spot	—	—	+	+	—	—	—	—	—	—	—	+

forward we have multiplied the complexities facing us. Even at this early stage of development of our understanding, we have exceeded the capacity of the human mind to make the necessary correlations and must turn to an electronic brain. Patients and normals react together, apparently to something common in their common environment. Patients who are clinically similar may be physiologically different. We do not know whether this reaction is causing disease or aggravating existing disease. Nor do we know whether it is due to factors in the community or in the home environment. It would appear that different patients not only react differently but may also react to different environmental factors, which in turn may act either singly or in combination. If this is so, we must not only sort out the possible environmental offenders, but must also be sure that we are relating them to the proper reactors in the population; otherwise we may completely miss significant relationships. Extensive as the air sampling and meteorological studies have been to date, they are barely minimum when com-

pared to our immediate and future needs. Until some specific central theme can be established, we must think in terms of evaluating the individual at home, at work, and in his community, in relation to an increasing number of measurable factors and combinations of factors.

The unraveling of the pressing problem of the relationship between air pollution and respiratory health requires the combined, coordinated effort of biochemists, physiologists, engineers, meteorologists, physicians, legislators, and the general population. It will not be an easy problem to solve but it should come as no surprise to us that nature is complex. Certainly, in the light of all of these complexities, only a coordinated approach in which each group thoroughly understands the problems and interpretations of other groups will lead to success.

Prepared Discussion: THE COMPLEXITY OF THE RELATIONSHIP BETWEEN AIR POLLUTION AND RESPIRATORY HEALTH

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First of all, I wish to congratulate Dr. Spicer for his convincing and challenging illustration of the complexity of the relationship between air pollution and respiratory health. He has demonstrated that serial airway resistance measurements in normal individuals and in those with chronic pulmonary disease vary in the same direction at about the same time. However, using multiple regression analysis, he found that the best correlation of the changes in airway resistance was with NO_2 (nitrogen dioxide) levels 24 hours prior to the pulmonary function study in one patient; in another patient it was with a combination of weather and pollutant variables; and in the third, the best correlation was with a decrease in environmental temperature on the afternoon and evening of the day before.

I submit that the problem is surely complex enough to allow room for many more investigators than are now in the lists. Again, I congratulate Dr. Spicer both on his excellent work and on having the spiritual courage to undertake and to persist in his studies.

Dr. Spicer's study primarily concerned the more or less direct, acute response to "irritation" by air pollutants. At this point let us introduce a rather neglected variable—a variable that Dr. Spicer and his group are studying—infectious organisms. Air pollutants possibly may increase the incidence, severity, or duration of respiratory diseases produced by bacteria and viruses. In addition, a synergistic effect of carcinogenic air pollutants and influenza virus in the production of pulmonary cancer in mice has been reported (*1*). Other reports of a synergistic effect of viruses and subeffective doses of carcinogens on experimental cancer production have been made (*2*).

Purvis, Miller, and Ehrlich have shown that exposure of mice to 4 parts per million of ozone for 3 hours resulted in an increased death rate from subsequently or previously administered *Klebsiella pneumoniae* (*3*). They have also obtained similar results with nitrogen dioxide. Clinical experience in man indicates that acute exposure to pulmonary irritants in obviously toxic concentrations also predisposes to pneumonia. However, Gorham has reported a correlation between the death rates from pneumonia in the United Kingdom and the deposit of atmospheric sulfates (*4*). This suggests that the more usual levels of air pollution may have an effect on either the incidence or the severity of pneumonia in humans.

Chronic bronchitis, one of the most important health problems in England, has been statistically related to regional air pollution by coal smoke, and to personal air pollution by cigarette smoke. Infection also plays a part. *Hemophilus influenzae*, pneumococci, and other organisms abound in the bronchial mucus of individuals with chronic bronchitis. Normally, the sublaryngeal mucosa is sterile. Bronchitic patients usually improve when treated with antibiotics. The inhaled air pollutants disturb the normal physiology and histology of the airways, making them more susceptible to bacterial invasion, an action which may, in the broad sense, be termed synergistic.

Pemberton and Goldberg demonstrated a significant correlation between the death rate in men over 45 from chronic bronchitis and the SO_2 (sulfur dioxide) concentrations in the county boroughs of England and Wales (*5*). Reid has demonstrated that the frequency of absence of British postmen in

heavily polluted regions because of chronic bronchitis was almost three times that experienced in the least polluted regions (*6*). Absences due to other respiratory diseases increased only moderately.

However, there is evidence that acute respiratory infections also seem to be affected by air pollution. Applications for hospital admission in London by adults with respiratory disease have been demonstrated to increase significantly, and independently of certain weather variables, during those months associated with an increase in concentration of smoke solids (*7*). In one study, colds were found to have been more frequent in an area of high dustfall (*8*).

Several years ago I became interested in the possible relationship between respiratory disease and air pollution (*9*). We had found an almost twofold intercity variation in the incidence rates for illness absence from all causes, lasting more than 7 calendar days, in the "hourly" women employees at eight plant locations of the Radio Corp. of America. Sociological and occupational factors, as well as age distributions, did not account for the differences. Intercity respiratory disease rates varied fivefold and accounted for 50 to 100 percent of the differences in the total rates.

The means of respiratory disease rates for the 3 years studied, and the suspended particulate sulfate concentrations in the air of the five cities for which these data were available, were calculated to have a correlation coefficient of 0.96. This is significant at less than *P*-0.01. The reasons for this high correlation are not known. If not a chance correlation, or due to an unknown common and possibly causally related factor, one must consider the possibility that respiratory disease is prolonged or increased by air pollution. This might occur because of bacterial invasion, chemical irritation, or impairment of the defense forces so that a higher proportion are ill more than 7 days. It is also possible that the inception rate is affected by increased host susceptibility to virus infections, or better transmission of the virus. These latter two mechanisms, although increasing the inception rate, would not necessarily increase the duration. Review of the six categories of respiratory disease which we studied indicates that mean durations for each of the categories are not correlated with the incidence rates.

If environmental factors play a role in the inception rate of clinically evident respiratory disease, a region subjected to the same environmental changes should exhibit concomitant variations in the incidence of respiratory diseases in separate but comparable groups. Employees of the Radio Corp. in Camden experienced "epidemics" of respiratory disease at about the same time as the employees of the Curtis Publishing Co., 1.4 miles away in Philadelphia across the Delaware River. A high degree of mixing of the two populations seems unlikely, since less than one-third of each population lives on the opposite side of the Delaware River from their place of work.

There is not enough information, as yet, to judge if the weekly means of the daily values of suspended particulate sulfates in the Philadelphia air show a significant correlation with the onset of the "epidemics" of respiratory disease (*10*). However, there was a large and significant decline in sulfate values in the spring prior to the marked decrease in respiratory disease.

Finally, we may ask: Is there any evidence that a decrease in air pollution is associated with a decrease in respiratory illness? Through the kindness of Dr. Robert Ayerle, we obtained the annual incidence of all illness absenteeism lasting 8 calendar days, or more, in employees of the Bell Telephone Co. working in Pittsburgh and Philadelphia for the years 1936 through 1958. During the 11 years before the vigorous air pollution control campaign was inaugurated in Pittsburgh in 1946, the illness rates in Pittsburgh, considered separately for the men and for the women employees, were higher than those in Philadelphia in 16 out of 22 times. After 1946 the Pittsburgh rates were lower than Philadelphia rates in 16 of 24 comparisons (*10*). The eight instances of higher rates were before 1953, by which time the "visibility index" had improved considerably. By chi-square analysis, the post-1946 change is significant at less than *P*-0.02. Unfortunately, incidence rates of respiratory disease were not available for the Bell Telephone employees; but our own experience indicates that it is the respiratory disease rates of comparable populations which vary most widely between cities.

It thus seems abundantly clear that the relationship of respiratory health to air pollutants is a complex one; that individual host response may vary; that pollutants and their combinations vary in kind, concentration, and effect; that weather variables are important; and finally, that the effects of air pollution on bacteria and viruses and their host's resistance must be considered.

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AIR POLLUTION AND LUNG CANCER

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The worldwide increase in the incidence of lung cancer has provided the epidemiologist and the experimentalist in the laboratory with a unique opportunity to jointly study factors concerned with the pathogenesis of this disease. The real and, at least until recently, progressive increase of lung cancer is etiologically associated with the contamination of our respiratory environment by carcinogenic agents and other environmental substances which serve to facilitate the action of these agents. The specific epidemiological pattern of lung cancer incidence is probably determined by a combination of these exogenous environmental agents as well as endogenous host factors. The major emphasis of this presentation will be directed toward exogenous factors, including polluted urban atmosphere, cigarette smoke, and viral infections. It must be emphasized that evidence for an exclusive environmental source or factor acting in the pathogenesis of lung cancer is lacking. Therefore, a discussion of air pollution and lung cancer independent of its relation to other environmental factors is unrealistic. However, sufficient epidemiological, clinical-pathological, and experimental data exist to incriminate polluted urban atmosphere as an environmental source pathogenetically related to the development of lung cancer. Since the chemistry of polluted urban air and that of cigarette smoke are remarkably similar, it is possible that much of what will be presented as being pertinent to the former will also be applicable to the latter.

Prior to discussing polluted air in relation to the other environmental factors concerned with the pathogenesis of lung cancer, it will be helpful to review the data which warrant its incrimination:

(1) Carcinogenic agents have been identified and quantitated in the polluted air of essentially all cities in which they have been sought.

(2) Chemical compounds with known tumor-promoting properties similarly have been identified and quantitated in polluted urban air.

(3) The stability and survival of carcinogenic hydrocarbons in the atmosphere are compatible with inhalation and a postulated biological effect in those exposed.

(4) Carcinogenic agents as well as noncarcinogenic respiratory epithelial irritants occur in the atmosphere in a physical state compatible with host entry and tracheobronchial deposition in exposed populations.

(5) Alteration in function and structure of the respiratory epithelium of representative mammalian species has been demonstrated following exposure to a broad spectrum of these environmental irritants. The resulting changes appear to facilitate the biological action of carcinogenic agents.

(6) Bioassay by skin painting and subcutaneous injection techniques has established the carcinogenic properties of compounds identified in and extracted from polluted air. Exposure of both susceptible and resistant strains of mice to aerosols of synthetically reproduced polluted urban air has resulted in the production of lung tumors in both strains.

A synthesis of the findings described suggests that the carcinogenic properties of polluted urban atmosphere provide at least two indispensable links in the pathogenesis of lung cancer. The first and most obvious is the environmental presence and the host entry of agents proved experimentally to be carcinogenic and epidemiologically associated with

by virtue of their effect on the ciliated mucus-secreting epithelium of the tracheobronchial tree, facilitate the deposition and abnormal retention of particulate matter in the lungs. Elution of the carcinogenic polycyclic aromatic hydrocarbons (PAH), 3,4-benzpyrene, and 3,4-benzfluoranthene, by host proteins from soot particles is thereby facilitated. A significant increase in the local concentration of liberated carcinogens results. Atmospheric irritants may, in addition, periodically and intermittently cause denudation of the superficial epithelium so that the basal cell layer is directly apposed to the carcinogenic stimulus. We regard this periodic epithelial desquamation followed by regeneration in the presence of a carcinogenic stimulus as providing a favorable environment for subsequent abnormal growth.

The experimental evidence cited is especially meaningful by virtue of its quantitative compatibility with the pattern of diseases seen in human populations at risk. There exist, however, numerous apparent inconsistencies when quantitative extrapolation of the experimental data is attempted. These include limited dose response relationships, relatively low attack rate in those exposed, and deceleration in the rate of increase in incidence at a time when latent period cohort increases of known and suspected carcinogens were accelerating at a maximum. We have instituted several studies in an attempt to explain or elucidate the basis for these inconsistencies. A few of these will now be described in detail and several others mentioned.

Anticarcinogenesis.—It has long been recognized that chemically related compounds may act upon one another in an additive, synergistic, or inhibitory manner. It has been observed in various fields of biochemistry that a biologically active compound—for example, a vitamin—may be prevented from displaying its effect in the presence of a closely related derivative (anti-vitamin). The latter probably plays the part of a competitor for intracellular receptors. Along the line of earlier investigators, we have been studying the effect of closely related PAH upon one another when administered simultaneously or at varying time intervals. Experimentally, it has been possible to demonstrate that even the most potent carcinogens can have their effect reduced or totally obliterated in the presence of proper proportions of inhibitors. This has immedi-

rette smoke, a broad spectrum of noncarcinogenic and weakly carcinogenic hydrocarbons are formed. Experimentally these latter compounds unequivocally exert an inhibiting effect, and, under actual environmental conditions, they exert, in all probability, a modifying or inhibiting effect on the total carcinogenic potency of the milieu in which they exist.

Multiple exposure.—It has been experimentally and clinically shown that tissues reacting to proliferative stimuli are at increased risk to neoplasia when simultaneously or subsequently exposed to carcinogenic stimuli. Experimental attempts to induce squamous-cell cancer of the lung by the exposure of mice to aerosols of carcinogenic hydrocarbons alone or to influenza virus alone have been uniformly unsuccessful. However, in a series of experiments just completed by us, exposure to these environmental agents in combination has resulted in the production of the specific human type pulmonary neoplasm.

Metabolism of carcinogenic hydrocarbons.—The basis for variations in response to environmental carcinogenic hydrocarbons is still an enigma. In an attempt to distinguish the susceptible from the nonsusceptible in an exposed population, we have been studying the metabolism of PAH. Experimentally it can be shown that interference with detoxification of PAH in the hepatobiliary system results in a delayed clearance of these compounds from the site of administration. Accompanying this there is a qualitative and quantitative alteration in the profile of metabolites recoverable from the bile. In parallel bioassay experiments, transient mild hepatic injury at the time of carcinogenic administration resulted in a significant increase in tumor yield in mice, when compared with controls, following administration of carcinogenic PAH. While the role of hepatic function may be but one of the many factors associated with responses to carcinogenic PAH, it is our belief that this factor is in all probability operable in humans and thereby contributes to differences in susceptibility.

Other factors almost certainly responsible for the epidemiological pattern of human lung cancer include: (1) the action of promoting agents, which though in and of themselves are noncarcinogenic, frequently determine the time of appearance and rate of incidence of malignant neoplasms; (2) the

presence of concomitant or antecedent pulmonary disease, which also appears to be significant since chronic bronchitis and tuberculosis are apparently associated with increased risk to pulmonary cancer; and (3) occupational factors, which in certain instances have been shown to be positively related to an increased risk to the development of lung cancer, and may have a more universal application than heretofore has been recognized.

From these limited examples, it is apparent that the hazard can be only partially defined by exclusive quantitation of carcinogenic agents in polluted air. The data also strongly suggest that even minute doses of carcinogens must be regarded as hazardous, even when dose response criteria in experimental species may suggest the absence of a hazard. Conversely, it must be emphasized that larger concentrations, though wholly undesirable, of course, may under certain circumstances represent minimal hazard.

This presentation of specific laboratory data has been included primarily to qualitatively denote the existence of a hazard in polluted air. Quantitative discussion, independent of the consideration of the significance of other environmental hazards, is difficult if not impossible.

Bronchogenic carcinoma represents one of the current critical problems in the field of pulmonary disease. Laboratory investigation can contribute much information to the ultimate solution of this problem. In the physical science area, finite analytical data are possible. In the biological realm, strong supporting data can be secured despite the fact that experimental investigations are necessarily limited to nonhuman animal species. It is necessary, of course, to remember certain deficiencies inherent in the biological studies. Choice of species, selection of appropriate animal strain, duration of exposure, concentration of test material, and routes of administration are all variables that modify the extrapolation of experimental data from other animals to man. Despite these limitations, past experience has shown a high index of meaningfulness of animal experiments for the human species. The broad spectrum of agents carcinogenic for visceral organs in experimental animals and apparently for man should make one proceed with caution in attempting to attribute absolute dominance of any one agent or source over another.

Epidemiologically, a reduction in lung cancer incidence may be properly anticipated as a result of reducing the concentration of carcinogenic agents in polluted air or any of the environmental sites discussed. It is our belief, however, that the reduction would be of a low order of magnitude in the absence of the removal of the remaining sources of irritants and carcinogenic agents from the respiratory environment.

AND LUNG CANCER

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The contamination of urban air by pollutants of various types and from various sources represents a problem which merits our full attention. The effect of such pollution can be immediate or extend over a period of years. It is the latter effect and its possible relationship to lung cancer that is under discussion here.

In studying air pollution, it is important that we include all of those factors that contribute to it, such as components resulting from combustion, industrial waste, road dust, and radiation. These factors must be studied, not only by themselves but also in terms of their interaction. Such a study requires the utilization of various phases of scientific research, including epidemiological and laboratory investigations.

We have recently reviewed the epidemiological evidence linking air pollution to lung cancer (*1*). We regard it as established that the urban population has a somewhat higher rate of lung cancer than does the rural population as shown by the study of Hammond and Horn (fig. 1) (*2*). Other evidence pointing to an "urban factor" as recently presented by Haenszel and his associates indicates that individuals who were born in rural areas but who lived later in metropolitan areas had a higher rate of lung cancer than those who lived in metropolitan areas all their lives. The authors present no explanation for this finding (*3*). The higher lung cancer rates of the urban population apply primarily to cigarette smokers. The recent survey by Haenszel et al. also indicates that for nonsmokers the difference in rates in urban and rural areas is "trivial" (*2*). A major problem of the epidemiologist in evaluating the factor of air pollution is that the correlation between cigarette smoking and lung cancer is of such an order of magnitude as to overshadow other factors (fig. 2). In evaluating the basis for the "urban factor," we must, in addition to air pollution as such, consider the more common occurrence in cities of occupations that have higher-than-average rates of lung cancer, the tendency of city populations to smoke more cigarettes than the rural population, and the fact that cancer in general is reported somewhat more commonly in cities (*1*).

It is apparent that factors of different natures, both exogenous and endogenous, may be involved in the induction of lung cancer. The epidemiologist should consider all these factors as far as epidemiologic techniques permit. Viral and bacterial infections, for instance, may also play a role here. Recent evidence from our own studies suggests that chronic bronchitis influences the induction of lung cancer in man. Laboratory evidence suggests a similar role for viruses in the experimental animal (*4*). It is conceivable that the "urban factor" may, therefore, also be related to certain lung diseases which may occur more commonly in cities. In this connection, studies on the possible influence of climatic factors as well as population

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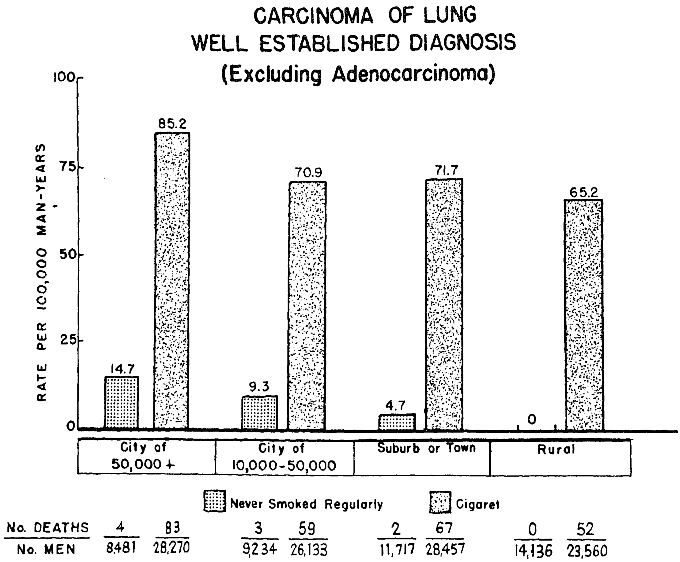
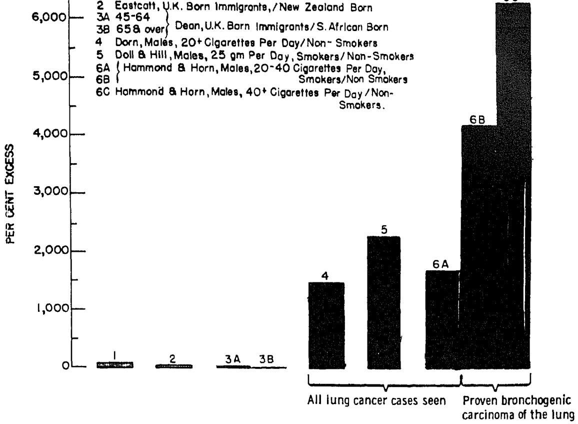


Figure 1

TABLE 1.—*Analysis of air pollution samples collected in Detroit in 1961* [1]

Sample	p.p.m. CO	mg Benzene soluble matter per 1,000 m³ air	Microgram benzo(a)pyrene per 1,000 m³ air	Microgram benz(a)anthracene per 1,000 m³ air	mg Lead per 1,000 m³ air
Highway Interchange					
2/28+3/1	....	53.5	13.7	14.7	11.8
3/1+3/2	....	62.8	9.2	12.5	8.3
9/9+9/10	6.1	39.0	6.0	8.1	9.9
9/18+9/19	6.3	52.3	4.0	7.5	9.5
10/4+10/5—(day)	7.1	40.6	7.3	8.2	11.3
10/4+10/5—(night)	3.9	37.8	3.6	4.2	6.2
Grand Circus Park					
4/11+4/14—(day)	....	47.5	7.2	12.6	5.2
12/5+12/6—(24 hours)	4.7	34.6	8.7	13.3	3.6
12/11+12/14—(day)	6.0	49.3	17.0	21.6	5.4
12/13+12/14+12/15+12/16 (night)	2.8	26.4	5.0	10.0	4.1

[1] Study group: Sloan-Kettering Institute and General Motors Corp.



GRAPH I

Relative Difference of Lung Cancer Mortality, Urban/Rural and Immigrant/Native Compared to Smokers/Non-Smokers.

Figure 2

density on the incidence of bacterial and viral infections of the lung may prove pertinent.

On the basis of present evidence, we regard as established the existence of a correlation of an "urban factor" to lung cancer. It remains to be proven, however, to what extent this factor is due to air pollutants as such.

Laboratory studies contribute to our understanding of the pathogenesis of lung cancer by investigating the interrelationships of various agents, such as air pollutants, cigarette smoke, infections, and possibly other factors in the experimental animal. We should like to outline some of the research activities of our group in this field. At present we are engaged in analyzing air pollutants obtained from various cities in a program conducted in cooperation with the Research Laboratories of the General Motors Corporation (*5*). Air samples are being analyzed for benzo(a)pyrene and benz(a)-anthracene, pyrene, and fluoranthene as indicators of polynuclear aromatic hydrocarbons, for phenol as indicator for phenolic components, for lead as indicator for the contribution of gasoline engine exhaust in a given air sample, and also for carbon monoxide and benzene-soluble matter (table 1). We are also studying the effect on air pollutants of such factors as sunlight, wind direction and speed, and other weather conditions, all of which affect the composition of a given air sample.

The exhaust from automotive internal combustion engines represents one of the sources which contribute to air pollution (tables 2 and 3) (*6–8*). The use of different fuels affects among others the emission rate of polynuclear hydrocarbons and phenols. These components are highest in exhaust obtained from pure aromatic fuels and lowest for pure aliphatic fuels (table 4). Their concentration in the benzene extract of gasoline exhaust "tar" is decidedly higher than that of diesel engine exhaust "tar." Biological studies have shown that as low as a 10-percent solution of a benzene extract of gasoline engine exhaust "tar" is carcinogenic to mouse skin (*7*). It is well known that man is not exposed to anything near this concentration of exhaust "tar."

TABLE 2.—*Polynuclear aromatic hydrocarbons isolated from gasoline engine exhaust "tar"* [2]

Hydrocarbon	Carcinogenic activity [1]	p.p.m.	µg./1-minute run
Benzol(a)pyrene	+++	32 [3] (72.6+3.6)	2.2 [3] (5.0)
Dibenz(a,H)anthracene	+++	3	.16
Benzo(j)fluoranthene	++	17	1.2
Benzo(b)fluoranthene	++	64	4.4
Benz(a)anthracene	+	62 [3] (131.4±6.5)	4.2 [3] (9.0)
Benzo(e)pyrene	+	422	29.0
Chrysene	+	175	12.0
Alkylbenzo(a)pyrene	?	1	.07
Alkylbenz(a)anthracene	?	2	.14
Alkylchrysene	?	67	4.6
Indeno(1,2,3-cd)fluoranthene	—	3	.18
Benzo(ghi)perylene	—	51	3.5
Perylene	—	Trace	Trace
Triphenylene	—	44	3.0
Pyrene	—	1,770	122.0
Alkylpyrene	?	8	.06
Fluoranthene	—	972	60.0
Alkylfluoranthene	?	261	17.9
Ideno(1,2,3-cd)pyrene	+	82	5.7
Anthanthrene	—	44	3.1
Benzo(k)fluoranthene	—	54	3.7
Benzo(ghi)fluoranthene	—	150	10.2
IIH-benzo(b)fluorene	—	51	3.5
Coronene	—	338	23.2

[1] Relative carcinogenic activity on mouse epidermis: +++, active; ++, moderate; +, weak; ?, unknown; —, inactive. (Obtained from own data.)

[2] Values based on material from the first run of the gasoline engine.

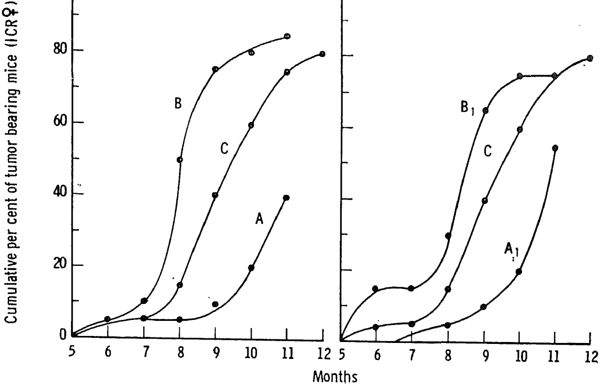
[3] Figures in parentheses indicate actual amounts present in the extract, calculated by tracer technique.

The interrelation of polynuclear hydrocarbons deserves further study. An interesting finding is that the addition of a 1-percent solution of known noncarcinogenic pyrene or fluoranthene accelerates the tumor production obtained with a low concentration of benzo(a)pyrene. In view of the relatively high concentration of these components in air pollutants, this observation may be of significance. This finding becomes more complicated by the fact that the interrelationship of these polynuclear hydrocarbons seems to depend at least in part on the dose level of the components (figure 3). It is further complicated by the fact that other polynuclear hydrocarbons, such as phenanthrene and benz(a)anthracene have an inhibiting action on benzo(a)pyrene. Thus, the interaction of polynuclear aromatic hydrocarbons presents a most complex problem.

TABLE 3.—*Phenolic compounds in gasoline engine exhaust per 1-minute run*

Compound	(µg)
Salicylaldehyde	Trace
Phenol	1,400
o-Cresol	1,600
m+p Cresol	2,700
2,5-Dimethylphenol	870
2,4-Dimethylphenol	1,200
3,4-Dimethylphenol	540
2,3,5-Trimethylphenol	330

Of particular importance are studies involving the interrelationship of initiating carcinogens and tumor-promoting substances. Studies with phenols, and more recently with terpenes, have again stressed that tumors may be obtained with rather minute amounts of polynuclear aromatic hydrocarbons if promoting substances are also applied to the mouse skin. In respect to the mass of data



A = b(a)p 0.005% + pyrene 0.004% (mol. ratio 1:1)
B = b(a)p 0.005% + pyrene 1.0% (mol. ratio 1:250)
C = b(a)p 0.005%

A_1 = b(a)p 0.005% + fluoranthene 0.004% (mol. ratio 1:1)
B_1 = b(a)p 0.005% + fluoranthene 1.0% (mol. ratio 1:250)
C = b(a)p 0.005%

Figure 3

TABLE 4.—*Benzo(a)pyrene, benz(a)anthracene, and phenol emission rates with gasoline and hydrocarbon fuels*

[Minute run]

Fuel	μg B(a)P	μg B(a)A	mg phenol
Gasoline	9.6	17.3	1.4
2,2,4-trimethylpentane	2.6	.8	.013
2,4,4-trimethyl-1-pentene	.7	.4	.059
50 percent o-xylene + 50 percent benzene	25.8	56.3	5.56
25 percent 2,2,4-trimethylpentane + 25 percent 2-methylbutane + 50 percent o-xylene	9.0	32.3	.46

obtained on polynuclear aromatic hydrocarbons in polluted air, we should like to caution against drawing a direct correlation between their presence in a given area and lung cancer rates. A plea is, therefore, made against so-called "benzopyromania."

Other studies pertinent to the present problem are experimental studies with possible cilia-static components. Cilia-static agents known to be present in both general air pollutants and in cigarette smoke can affect the flow of mucus and thus affect the resorption of various components from air pollutants, as well as from tobacco smoke. In respect to inhalation studies it should be stressed that a final objective should be to stimulate the human setting as closely as possible, particularly in terms of dose applied. These studies should also include investigations on the possible relationship of chronic bronchial infection to the development of lung cancer in the experimental animal.

It is apparent from the present discussion that the final evaluation of the effect of air pollution on lung cancer demands coordinated efforts of various disciplines of medical science.

In summary, epidemiological data have established an "urban factor" for lung cancer, the exact basis of which, however, remains to be determined. Laboratory data have presented several factors that in the experimental setting contribute to the induction of cancer. In view of these considerations, in addition to other health problems associated with air pollution, a reduction of pollutants in the atmos-

phere is certainly a step to be desired. Work in the field of air pollution is essential, not only because of the potential health problems, immediate and distant, that are involved, but also because of the general scientific knowledge we can gain. These studies will contribute to knowledge of the possible interrelationship of carcinogens, cocarcinogens, anticarcinogens, cilia-static components, and infectious agents as well as possible climatic factors on the induction of lung cancer. It is our hope that a further understanding of the action and interaction of these factors may lead to a reduction or modification of those factors that contribute to the induction of lung cancer.

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Biometeorology deals with the effects of the atmospheric environment on life processes. Even though such influences were well recognized by the ancients we are still trying to reduce the innumerable interrelations between the life complex and the events in the air to an exact science. Like its sister sciences with the prefix "bio" (such as biochemistry, biophysics, and bionics) biometeorology promises important results.

The subject covers a wide range of relations. Most of them can only be enumerated in passing. Among these is the wide realm of interrelations of climate with the earth's plant cover. Another broad subject is the reactions of normal animals and humans to solar radiation, to atmospheric heat and cold, and to humidity and its combination with various temperatures. Much has been written but little firm knowledge exists about pathological influences of the atmospheric variations. Yet there is no doubt about the existence of meteorotropic conditions. These center around such manifestations as scar-tissue and rheumatic pains, circulatory disturbances, and vegetative nervous reactions. Interesting as all these may be, we would like to concentrate in the context of this conference on the problems connected with the respiratory diseases. All of these are closely associated with the atmospheric surroundings and especially the atmospheric suspensions, which we can just generally designate as aerosols, even though strictly speaking some of these are gaseous admixtures to the air.

One may speculate as to whether or not it is just coincidence that the respiratory organs are affected by more diseases than the other parts of the system. It is a long list indeed: asthma, bronchitis, bronchiectasis, common cold, diphtheria, emphysema, the influenzas, the pneumoconioses, the pneumonias, laryngitis, phthisis, pleurisy, tuberculosis, whooping cough. Several of these are directly caused by specific micro-organisms. Others appear as general irritations of the affected organs. Even for those that are microbially induced, the atmospheric environment either seems to create circumstances favorable for the infection or has a direct effect on the existence or virulence of the causative micro-organisms. A notable example is the apparent inability of the common cold virus to persist as a pathogen for any appreciable time in outdoor polar environments.

Quite direct and specific are the relations between various irritants suspended in the atmosphere and certain allergies, different plant pollens being the best known cause among them. In contaminated air, dusts of various types are the causation of disabling ailments. To these, modern industry and transportation have added a long list of contaminants. In order to appreciate the changes that man has brought about in the atmospheric environment, it seems desirable to reconstruct just what natural air is like. With the rapid transport of suspensoids by the planetary wind system, it is doubtful that in the present age there exists any uncontaminated air at all. Although the degree of contamination varies, and is heaviest around industrial centers and cities, very small particles and gases rapidly diffuse on a worldwide scale and become ubiquitous. If there had ever been any doubt about this, the nuclear tests, aside from adding their own share to the pollution, prove this point beyond doubt.

Not too many generations ago, air had as constituents only nitrogen, oxygen, argon, carbon dioxide, water vapor, and the rare gases neon, argon, krypton, and xenon, plus traces of ozone and helium. The aerosol comprised occasionally liquid water and a few hundred condensation and freezing nuclei per cubic centimeter, mostly derived from ocean spray. Many of these were charged, as large ions, which formed by the attachment on the

fine dust of small ions, produced by cosmic rays and soil radioactivity. There was usually a small surplus of negative charges present. Biologically important and active were primarily the oxygen, the carbon dioxide, and perhaps the ions. Contaminants were rare, although not entirely absent. These consisted of sand and dust raised by occasional strong winds, gases and ashes from a rare volcanic eruption, and smoke from lightning-induced forest fires. Aside from the relative rarity of these events and the sparse settlement of the globe, the evolutionary process has equipped mankind with a very effective elimination system for solid contaminants. It is highly probable that aerosols, primarily composed of fairly sizable dust particles, were the most common, if not the only, natural aerosols which early man encountered at reasonably frequent intervals.

The anatomy and physiology of the upper respiratory passages are quite well suited for dealing with solid suspensions. And if we assume that this is due to hereditary adaptation to the environment, these suspensions were the primary aerosol hazard to which man was exposed. It has been estimated that the filtration and elimination system of the upper respiratory and bronchial tracts is 99.8 percent efficient (Nückel, 1962). This is extremely effective for what can be expected in a natural environment, particularly if one considers that the naturally occurring hygroscopic particles would rapidly grow to sizable droplets in the moist passages. Hence, we can probably state unequivocally that, aside from allergy-producing particles, the human being is admirably equipped to cope with natural aerosols.

This is not the case when we consider manmade aerosols. Many of these fall in the size classes which penetrate deeply into the respiratory system, and their chemistry often makes them act as irritants. For the dusts we can get some very accurate ideas on how much and where they are absorbed into the tissues from the autopsy material on pneumoconiotic persons.

To this we must add the fact that many manmade contaminants are irritant, poisonous, or pathogenic. The number of these contaminants has grown to such an extent that one could list several pages of them. Only a few will be cited here. The first is solid dust. Most of it falls out rapidly or is washed out of the atmosphere. We have already noted that the respiratory elimination process is also fairly efficient to cope with it, although we have to figure that the city dweller will strain daily at least 10 million million particles through the air passages.

A great deal of work has been devoted to these solid contaminants, often collectively classed as smoke. There is no doubt that this is the effect of air pollution which is most notable. It can be detected by the naked eye. It is most readily measured by fallout collectors, filters, and Ringelmann charts. The amounts of these solid deposits are truly staggering. In most industrial cities of the world they run around 100 tons per square mile per month. They stay very close to their source. There is no specific evidence of direct harmfulness of these suspensions to humans, although we should be aware of the fact that in concentrations of 200 $\mu g/m^3$ the minimum daily ingestion is 2.4 mg/day or nearly 900 mg per year. It is more likely that measurements of this dust concentration are useful as a symptom of other contaminants.

These particles have one physical effect, the biological importance of which is as yet unexplored. They change the ionization balance preponderantly to heavy ions with a surplus of positive charges. Another curious and unexplored phenomenon is the fact that the number of microorganisms in the air goes up with the number of particles.

There is evidence that the natural aerosol is essentially neutral. The manmade aerosol on the other hand tends to be commonly acidic. This is the consequence of higher percentages of CO_2 (carbon dioxide) and SO_2 (sulfur dioxide) in contaminated air. Both of these constituents are the end result of nearly all combustion processes, whether they result from coal, oil, or natural gas. They also are invariably an end product of diesel or other engine exhaust. There is good evidence that such an acidic aerosol causes a disruption of the lung epithelium and permits the penetration of other irritants or harmful substances into the tissue (v. Hayek, 1955). In the case of SO_2 irritation, this is certainly one of the major modes of action of air pollution. Some of the most notorious episodes with many fatalities show accumulations of this gas. The London smog of December 1952 is probably the most notable instance. There are now other well-documented cases. Aside from deaths of persons already burdened by severe cardiac or pulmonary afflictions, in all these episodes the death rate ascribed simply to bronchitis generally rises rapidly and in almost direct propor-

to emerge from several studies. As for most major episodes of dangerous pollution concentration, low windspeeds and temperature inversions are primarily responsible. Bouman and Schmidt (1961) have shown that the concentrations rise under those circumstances as functions of the square root of time, given constant output. In the London case of 1952, the SO_2 values increased in 4 days from 20 to over 100 parts per 100 million. Work carried out in Leningrad (Lenshin, 1958) has shown a strong inverse relation to the air temperature. The lower the air temperatures, the higher the SO_2 concentration during the cold season. This is a dual effect.

Intense inversions, of course, are connected with the lowest air temperature near the surface. At the same time, assuming essential constancy of all other sources, low temperatures will increase the rate of fuel consumption for heating and thus produce these results. In this connection it should also be noted that hydrolisation of SO_2 to H_2SO_4 (sulfuric acid) will take place when fog forms, a meteorological event which is not uncommon under low wind and inversion conditions (Bushtuveva, 1954). Little needs to be said about the irritating properties of this pollutant.

As far as general concentration of SO_2 is concerned, under normal daytime meteorological conditions with temperature lapse, it follows an exponential decrease from its sources. This has been well demonstrated from the Nashville study (Larsen et al., 1961). Under inversion conditions the local orographic setting will become a governing factor. Under those circumstances micrometeorological effects, often of the nature of gravity flows, will determine the concentrations. For this reason pollution problems are often locally aggravated in mountainous or rolling terrain.

The meteorological conditions related to accumulations of CO (carbon monoxide) are about the same as for SO_2. The source strength of CO is usually much more varied. The principal origin in cities is probably motor vehicle exhaust. It is higher in areas of congested traffic rather than where traffic flows smoothly. In suburban areas the concentrations, both in medians and extremes, are reports of concentrations as high as 350 parts per million in London. For Los Angeles the daily production from motor vehicles has been estimated 8,700 tons CO/day. Some studies on the carboxyhemoglobin content of the blood of exposed individuals have been conducted. Among traffic policemen in Hamburg, Germany, this has been measured at about 10 percent (Effenberger, 1957), a figure which compares well with earlier data from the Holland Tunnel in New York (Sievers et al., 1942). Apartment dwellers in cities apparently have a level of 2 percent carboxyhemoglobin. The concentrations are equal to those found after smoking. The health effects are quite controversial, with opinions ranging from the view that CO is of no consequence to assertions of circulatory and nervous damage. Meteorologically the concentrations are kept reasonably diluted as long as winds of 5 or 6 mi./hr. are maintained. This is common in most localities in daytime. At night, in some places calms or near calms are so frequent that it is fortunate that most sources are much reduced during those hours. Motor exhaust is also responsible for two other obnoxious products: lead and benzpyrene. The former in American cities shows maxima in the range from 0.3 to 17 $\mu g/m^3$ in various localities, with the most frequent values around a 0.6 $\mu g/m^3$ value (Tabor and Warren, 1958). The cancer-producing benzpyrene was found to be in cities mostly in the 5 to 15 $\mu g/1{,}000m^3$. London, England, has again the doubtful distinction of values as high as 300 $\mu g/1{,}000m^3$. Rural areas in the United States have generally lower values than cities (Sawicki et al., 1960). Here again the weather conditions play an important role. The localities and seasons with inversions show at times distinctly high concentrations.

So much has been said and written about ozone as a pollutant that we will mention it only in passing. It is photochemically produced by ultraviolet solar radiation. Ozone itself is an irritant but where it is obnoxious as a pollutant it acts probably indirectly by producing other irritating substances.

The meteorological conditions in most localities of the United States are sufficiently well known to

permit fairly good estimates of the pollution potential. Given an idea of the source strength the meteorologist can give a fairly well educated guess as to the possibilities and frequency of high concentration levels of pollutants in cities. Such guesses do not lead to a very optimistic outlook in many places. In some climatic regimes, unpleasant episodes of air pollution are meteorologically probable several times a year. In others they occur with lower frequency, perhaps only once in 2 or 5 years. Yet if these meteorological circumstances find the right orographic setting and substantial sources of pollution, the stage is set for another Donora episode.

In order to carry out some of the probability estimates and institute a realistic warning system, it would be desirable if air hygienists could agree on limits of dangerous concentrations for the most common and ubiquitous pollutants of city atmospheres. The limits now set are sometimes so far apart as to appear useless. Take CO, for example; the U.S. industrial standard limit is 100 parts per million, the California limit is 30 parts per million, and the U.S.S.R. sets it at 2 parts per million. For SO_2 we have a U.S. industrial value of 5 parts per million, a California value of 0.15 part per million, a U.S.S.R. value of 0.1 part per million. For lead we find values ranging from 0.2 mg/m^3 to 0.7 μ/m^3.

Another element in the biometeorology of air pollution is wafting. This describes the condition when pollutants are blown from their place of origin to another downwind location. On a small scale this takes place when factory chimney soot is deposited a few hundred yards downwind on the clean laundry in a backyard. On a large scale this can take place when a large source region, such as an industrial city, lies upwind of another locality. As urbanization of vast areas seems to be foreshadowed by the population explosion, this is a condition which has to be definitely faced. In some areas the meteorological conditions favorable for such events exist.

We should close this review on an optimistic note. The self-cleansing properties of the atmosphere are generally very good. Fallout and washout handle a lot of pollution. Wind, turbulence, and convection diffuse and dilute the gaseous pollutants quite well. We can predict with reasonable accuracy the dangerous atmospheric regimes. If we could add to this a suppression at the source of the most dangerous and obnoxious substances—a postulate entirely within the realm of feasibility of the technology—there need not be any air pollution morbidity.

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We have heard this morning reports on morbidity and mortality from air pollution in which specific instances were reviewed of five acute episodes of air pollution which occurred between 1930 and 1955 and affected the public health. Also discussed were acute illnesses and chronic diseases relating to air pollution and some of the physiological responses to specific air pollutants. We had a very detailed presentation of the physiology of the respiratory system and the complex responses of both man and animal, with the very evident indication that different people react differently to the same environment on a day-to-day basis as well as to specific individual pollutants or to combinations of various pollutants. The individual, in order to be evaluated properly, must be studied in the home, at work, and in the community, in respect to the increasing number of factors and combinations of factors in his environment. The synergistic effect of air pollution and infectious organisms was discussed and it was postulated that this may explain the increased incidence, severity, or duration of respiratory diseases produced by bacteria and viruses.

From what has been said this morning, we might readily draw two conclusions. No one will argue the point that the general public in many localities is adversely affected by air pollution. Complaints are bitter, there is economic loss, and many families have moved to less polluted areas. On the other hand, we have yet to prove the etiologic relationship of air pollution to chronic diseases involving the pulmonary system, the circulatory system, or the nervous system.

The correlation between air pollution and lung cancer, in which the chemistry of air pollution and that of cigarette smoke were reported to be remarkably similar, may lead one to believe that if one lives in a city which has air pollution, from a health standpoint one cannot afford to smoke cigarettes. The discussion of pulmonary physiology relating to aerosols, particulates, and gaseous agents leaves little possibility of an escape mechanism for humans who smoke or who are in "dirty air." Sooner or later, continued exposure to such environmental pollutants will overcome the defense mechanisms of the human body and progressive pulmonary pathology will develop.

The explanation of the part that weather plays in air pollution and of the results of man's wasteful habits is not only timely but is also an essential part of this panel's discussion. But, as many people say, we are unable to control the weather, so we must direct our attention to those areas in which man can do something about the problem he has created. Not only is man responsible for his individual acts but man collectively must also assume more responsibility in regard to his community activities. Man has, by his wasteful habits, despoiled the land on which he lives and the water on which he depends, and now he is contaminating the air which he breathes.

There is a great similarity between water pollution and air pollution. The waste-assimilative capacity of both receiving bodies varies with the dilution, the degree of toxicity, and the factor of time. The problems of correcting water pollution have had considerably more attention throughout the years. These problems have been much simpler to solve because of the development of control procedures and the construction of the necessary works to eliminate the problem. Air pollution in the broad sense has had relatively little study compared with that of water pollution and only now is man concerning himself with the

preservation of one of his most vital resources—ambient air.

The observation here today has been that there is a considerable variance in the air quality standards which have been adopted to date. One of the difficulties in adopting air quality standards is the necessity that such standards be based on sound data and concurred in by scientists in air pollution and related fields. When one searches the available literature for research findings that can be applied to air quality standards, one finds much irrelevant material and scanty specific references to specific air pollution effects on man. One might surmise that we have entered the era of community concern rather belatedly and that much more detailed information must be procured before we can set more precise standards. There has been some work done on laboratory animals with specific pollutants but the findings are difficult to apply to man. We have leaned heavily on working environment standards and have tried to relate them to community air standards and extrapolate the values.

We have a complex community environment in which many different processes are all actively going on, with some of the pollutants from those processes eventually finding their way into the ambient air. In many instances, we must expect the occurrence of an uncontrollable umbrella (inversion phenomenon) over the large metropolitan complex, which many times clamps a lid on the air basin. All of this provides a paradise in which the experts in bio-organic chemistry can study the various chain reactions which take place under ideal conditions and the unknown factors involved and their chemical relation and reaction one to the other. One must assume that, sooner or later, man will be unable to adjust as he does in certain of the studies reported here today, and will no longer be capable of living in his contaminated ambient air environment.

One would question the feasibility of concentrating population groups and industrial processes in certain geographic and meteorological basins when we do not know all the chemical reactions which take place nor can predict the frequency or the duration of the inversion phenomena in certain of the air basins. Perhaps the growing air pollution problem may not be completely resolved by control programs. Even though man has demonstrated a remarkable ability to adjust to an ever-increasingly polluted and contaminated environment, technologists have not yet demonstrated an equal ability to develop efficient and economical control systems which will keep pace with our ever-increasingly technological society and allow man to continue his present-day activities. If we are unable to plan man's ecology on this earth so as to prevent insidious health effects and air pollution disasters, perhaps it is wise that the U.S. Government and other world powers are giving an increasing amount of their attention to exploring outer space. It may be time for us to think of occupying and despoiling another planet so that man may continue to exist in the future development of our highly technological society.

medical school has been in Jersey City, we have
:n rather frequently plagued with statements both the press and from our scientific colleagues that w Jersey pollutes the air of New York City. We l not take this seriously at first, but in the past r years we decided that we ought to study in a le bit greater detail the air pollution problem our community and also to study the effects of pollution on health. We also are interested in ating our findings to the findings of the British using techniques similar to theirs. Therefore, out a year ago we undertook a survey which con- ed of a respiratory questionnaire, a simple monary function test, and a 70-millimeter chest ray. This survey was aimed at determining the valence rates of chronic respiratory symptoms ong men living in the Jersey City housing proj- . Our epidemiologic definition of chronic nchitis was adopted from the British as a onic productive cough present during most of : days of the month for at least 3 months of the ir. We interviewed men between the ages of 40 l 59 years. The population was relatively small; percent of our defined population (435 men) perated in the survey. Twenty-one percent of se men had chronic bronchitis. Eight percent them had chronic bronchitis, plus a history of urrent chest illness for the past 3 years. Five cent of them have a history of bronchitis plus abling dyspnea. Three percent had chronic nchitis, plus both disabling dyspnea and a his- y of recurrent chest illness. On the simple lmonary function test, the 1-second forced expi- ory volume showed that men with chronic piratory symptoms had a significant decrease in s reading compared to nonsymptomatic men. In sey City one aspect of air pollution that we died in detail was average surfur dioxide levels, ich over a 9-month period in 1961 and 1962 nged from about 0.18 to 0.20 part per million. ese levels are at least four times higher than those served in suburban areas in northern New Jersey. is seems significant to us, but when we look at our pulation, we also must admit that 30 percent of : cigarette smokers have chronic bronchitis, ereas not one of the noncigarette smokers was so ubled. Comparing our results with those of the tish, we found that the prevalence rates of onic bronchitis for Jersey City men fell between the saturation of cigarette smoking in our population makes it a little difficult for us to determine just what role air pollution does play. We feel that only by following the natural history of chronic bronchitis in the men that we have identified as having it shall we be able to answer this problem. We are interested in relating not only the environment factor of respiratory symptoms but also the role of bacterial respiratory infections.

Geoffrey L. Brinkman. Dr. Spicer beautifully demonstrated the complexity of relating environmental factors to human health, and I want to mention a study we've done in Detroit which illustrates some of the difficulties.

TABLE 1

Occupation	*Number*
Group 1: No industrial exposure	175
Group 2: Industrial but no silica exposure	598
Group 3: Silica exposure for more than 20 years; normal chest roentgenogram	404
Group 4: Silica exposure for more than 20 years; roentgenogram showed silicosis	140
Total	1,317

Table 1 shows the group we studied, around 1,300 men, all full-time workers, ages 40 to 65. Group 1 is a group with no industrial exposure, hospital personnel and executives, who had no known occupational exposure to dust. Group 2 is a conventional industrial group. Groups 3 and 4 had both worked over 20 years in a foundry which is not well known for its cleanliness. Figure 1 demonstrates the prevalence of bronchitis, which was defined as having a cough productive of at least a teaspoonful of sputum a day for at least 4 of the previous 6 months. Notice that, contrary to what you might expect, the top group, Group 1, is the executive group which had no known exposure to occupational dust, yet its members had by far the highest incidence of bronchitis. Now why should Group 1 have the highest incidence of bronchitis? One factor was that this group had the highest incidence of cigarette smoking. In the foundry the men are not permitted to smoke for at least 8 hours of the day, whereas the man sitting at his desk is free to smoke throughout the day. Figure 2 shows the importance of cigarette smoking.

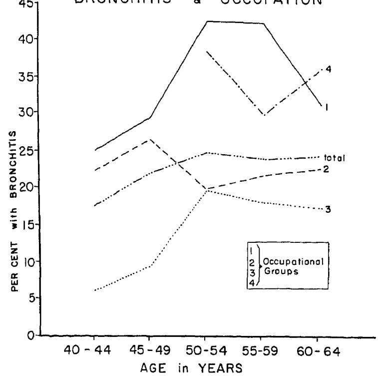

Figure 1

In nonsmokers the prevalence of bronchitis ran about 10 percent. Contrary to Dr. Gocke's findings in New Jersey, bronchitis in moderate smokers ran about 25 percent, and in the heavy smoker, it went up to 50 percent at age 50–55, following which there was a falloff, which is due to the fact that some of these men became disabled and were pensioned off.

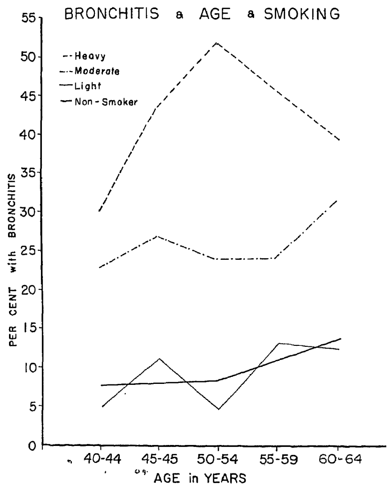

Figure 2

Frank L. Rosen. What is the incidence of bronchial asthma in the Los Angeles area as compared to other large cities in California, such as San Francisco, and to other cities in the United States?

Goldsmith. First, I have to clarify what Dr. Rosen means by incidence. This is a technical term and I assume he refers to frequency, which is customarily described as prevalence. But this is a minor distinction. The answer is that there is no discernible difference between the rates of asthma as reported by the California Health Survey, for example, between Los Angeles and San Francisco. If anything, San Francisco is higher; the difference is of dubious significance. As a further answer, to something which was not asked, we have also studied the prevalence of asthma in relation to the amount of pollution in specific areas in Los Angeles, and again, since the figures are of modest magnitude, I would not allege that they are necessarily significant. We find, and we have speculated upon this, that in the heavily polluted areas in Los Angeles there are very few cases of asthma. This leads us to wonder whether or not some of the people who have had the illness may have chosen to move from these areas. In reference to other cities in the United States, I can report that the highest level of asthma I know of in the United States is in Honolulu. I mention this without discussion.

S. S. Epstein. I wish to report briefly on some current studies at the Children's Cancer Research Foundation in Boston, the object of which is the development of a simple and rapid biological technique for assaying the carcinogenic potential of polluted atmospheres in terms of their content of 3,4-benzpyrene. 3,4-benzpyrene, in particular, and other polycyclic hydrocarbons to a varying but lesser extent, possess the property of photodynamic toxicity, as evidenced by their ability to sensitize cells to otherwise nontoxic longwave ultraviolet radiation. The photodynamic toxicity of pure compounds such as 3,4-benzpyrene is simply demonstrated by incubating aqueous suspensions of these materials with motile cells such as *Paramecium caudatum* in the dark for 2 to 3 hours, followed by irradiation at 3,660 Å. Under these conditions a lethal effect, proportional inter alia to the carcinogen concentration over a range of 10^{-5} to 10^{-11} gm/ml, can be directly observed.

Using standardized techniques, a series of crude benzene extracts of air particulates and chromatogramed fractions thereof (kindly made available by Drs. Falk and Sawicki) have been tested for photo-

The following aspects of the photodynamic assay may be contrasted with the conventional mouse skin carcinogen bioassay: (1) rapidity and simplicity, and the fact that information may be obtained in the course of a day and not a year or so later; (2) economy; (3) the small size of the samples required (10 milligrams of a tar is more than adequate); (4) the test does not appear to be influenced by anticarcinogens, promoting agents, and nonspecific irritants.

Theron G. Randolph. I am speaking as a practicing internist and allergist.

Attempts to appraise the clinical significance of the air pollution problem, as far as chemical exposures are concerned, must begin with the realization that there are two major divisions of the subject. One has to do with outdoor chemical air pollution, which you have heard discussed from various standpoints. Equally important is the subject of indoor chemical air pollution. In my experience, this indoor air contamination is such a frequent cause of chronic illness in susceptible persons that it must be evaluated and preferably controlled before one is justified in drawing deductions as to the clinical significance of chemical contamination of the outdoor atmosphere.

Although outdoor chemical air contaminants enter homes located in contaminated areas, chemical air contamination arising within a patient's living quarters may occur irrespective of the location of such dwellings. The major sources of such contaminants are odors and fumes arising from leaking utility gas or the combustion products of gas, oil, or coal. The gas kitchen range, gas-panel heating units, and fuel-oil space heaters are the most significant, although appreciable air contamination is also derived from hot-air furnaces (irrespective of the type of fuel used), sponge rubber padding, bedding and upholstery, insecticides, paint odors, disinfectants, and various other odorous household materials. Contaminated air from the garage also often enters the house.

These relatively constant sources of indoor chemical air pollution are rarely suspected as inciting and perpetuating causes of chronic illness. Only as patients are maneuvered in respect to these exposures may acute reactions be observed which demonstrate cause-and-effect relationships. For instance, on the basis of observing clinical effects over 800 such devices have been removed permanently from the homes of highly susceptible persons.

A wide range of chronic illnesses result from such day-in and day-out hydrocarbon exposures. The most serious are depressions and other advanced psychotic states (Randolph, T. G.: Ecologic Mental Illness—Levels of Central Nervous System Reactions, Third World Congress of Psychiatry, vol. 1, University of Toronto Press, 1962). Lesser grade cerebral reactions manifest as mental confusion and brain fag as well as physical fatigue. Closely related manifestations are rheumatism, arthritis, myalgia, neuralgia, headache, and related musculoskeletal and neurological syndromes. Any of the responses ordinarily considered as allergic, especially stuffy nose, coughing, bronchitis, bronchial asthma, are also commonly on the basis of susceptibility to airborne chemical contaminants.

Finding and avoiding these home environmental incitants impinging on the physical and mental health of susceptible persons is opening a new experimentally orientated medical approach to many chronic illnesses.

Goldsmith. I should like to say one thing about Dr. Randolph's very interesting observations, which doesn't in any sense conflict with them. That has to do with the value of staying at home during periods of severe air pollution. It's important, as Dr. Randolph emphasized, from all the facts we know, and they of course are not adequate, that in a severe air pollution episode in any major metropolitan area, including London or Los Angeles, there is every reason to recommend as a public health measure that the people who may be most susceptible to air pollution do in fact stay at home. Perhaps they should keep their ranges off, but at least they should remain indoors.

Monroe G. Sirken. My question was touched upon by the two previous speakers. Much interest is centered on the air pollution outside, but people live most of the day inside. To what extent can we get a measure of the exposure inside by knowing what the air pollution is outside? I don't mean the additional inside air pollutants such as Dr. Randolph discussed, but rather whether or not we are getting an accurate measure of the exposure of a person who spends 16 hours of the day inside a building when we measure the level

of air pollution outside the building. Dr. Landsberg, what about the person who's working in an air-conditioned building and living in an air-conditioned apartment? This seems to be the growing trend in our larger cities.

Landsberg. First of all, we do have some parallel measurements between pollutants indoors and outdoors, at least on particulate matter. Generally one thing is very obvious and that is that the indoor pollutants follow the trend of the outdoor pollutants. They may not be at the same level, but the variation is almost exactly the same. Apparently the buildings of normal construction in which we live have a high diffusion coefficient and sooner or later there is an adaptation to the outdoor condition. You cannot seal a building; building codes prohibit you from sealing a building in fact, because of the danger of asphyxiation. As to the second part of the question, on an air-conditioned building, that depends very much on the type of air conditioning. We do have some information on that, too. If you have an air-cooling system which simply cools and circulates the air, the level of pollution in a ventilated building may be a little higher than outdoors, because everything that usually would settle is "stirred" by the airspeed inside the building. Hospitals in particular are horrible in that respect. We have a few measurements on filtered air which show that much depends upon the filter. Most filters are quite efficient with respect to pollen, and that was the purpose for which they were constructed. Some filters moisten the air, making the particles heavier, so that they sink to the ground and, if you do not stir them up, pollution is lessened. We have very little information on the exact chemical composition of indoor air. From what we do know, it seems that indoor air is worse air than outdoor air even when the latter is polluted, because of the gas ranges, the fireplaces, the house dust, and other allergens that are present. Hygroscopic particles, which exist in large quantity outdoors, are eliminated by the filters in the air-conditioning systems. Some of the modern air-conditioning systems which continually recirculate the air and refilter it efficiently leave it almost free of pollutants, but we must remember that even then some of the gaseous pollutants stay. Carbon monoxide is not eliminated. Sulfur dioxide is generally altered, but it stays as sulfur trioxide or something of that type, so we are not completely protected by air conditioning. Biometeorologically speaking, we do not know whether the elimination of the diurnal rhythm is really good for people. In other words, whether or not living in a completely even environment is healthy has not been established.

Sidney Weinhouse. Would Dr. Kotin or Dr. Wynder estimate the approximate number of lung cancer deaths attributable to urban air pollution, and the extent to which stationary and automotive sources contribute to lung cancer?

Kotin. I'll vouch for the fact that polluted urban air as reproduced in the laboratory will induce lung cancer in experimental species. Whether or not any environmental source unequivocally alone produces lung cancer requires a degree of speculation and, as I said some years ago, it depends on how heroic you are in attempting to extrapolate. Certainly, elimination of the two most widely suspected environmental sources of carcinogenic agents would unequivocally result in a reduction in the lung cancer rate. We have no basis for outright guessing, and it would be guessing to estimate what the actual reduction would be with the elimination of one or the other factor. I suspect that a significant reduction would occur with the elimination of either, a fantastic reduction with the elimination of both. You also asked that we comment on the incidence of lung cancer of the adenocarcinoma type now presumed due to chemical carcinogens, and I emphasize the word "presumed." Certainly, the house of cards that related morphology to etiology over the past few decades is beginning to tumble. We know of no unique morphologic response to an environmental agent in which, by looking at the response in the intact host, you can identify the agent. There are certain paradoxes in terms of carcinogenesis as a discipline when one looks at the whole problem of lung cancer. For example, squamous cancer is termed "environmental cancer," and in studies it has been shown consistently to occur at a later period of life than do the other forms of cancer to be presumed nonenvironmentally related. This in no way negates the association. It does indicate that the complexity to which we give lipservice is perhaps more complex than we realize. There really is no pure type of lung cancer histologically, and as a corollary, relating it through specific environmental factors is, at least with pathologists, extremely hazardous. A lot of this sounds like doubletalk. That is because the information does not yet exist. To conclude, eliminating polluted urban air would result in a reduction in the incidence of lung cancer. Eliminating ciga-

reduces the likelihood of getting lung cancer and that the reduction becomes greater with length of abstinence. The point of urban-rural risk has been tackled by Hammond and Horn in another study. They standardized for the amount of cigarettes consumed and discovered that a city population of 50,000 or more has a death rate from lung cancer that is about 20 percent greater than that for the whole population, for both cigarette smokers and noncigarette smokers. It is possible that if they had standardized in addition to amount of cigarettes smoked, for degree of inhalation, and for butt length of cigarettes smoked and for possible occupational differences, the differences might have disappeared altogether. It is hoped that Drs. Hammond and Horn will produce in their projected new study enough detail on all these points so that they can determine whether the person who smokes, let's say, 20 cigarettes a day, lives in a rural area, and does inhale, and smokes his cigarettes three-fourths down, has the same rate of lung cancer as the same individual living in the city, or a different rate. Of course, matching for occupations would also be necessary. We know that certain occupations affect the rate of lung cancer. Like Dr. Kotin, I also would not dare to make a prediction. It has been well established that among noncigarette smokers today, lung cancer is a most unusual disease, in this country and in Great Britain. The question really is: How much does air pollution in addition contribute to your chances of getting lung cancer if you are already a cigarette smoker? As I indicated, there is an urban factor, in the United States, as well as in England, but in my opinion, there is no established proof, at least in the United States, that it is due to air pollution.

It is possible that in England with special climatic and coal-burning problems we have a very select set of circumstances. Frequent lack of central heating and a habit of sleeping with open windows even in winter must also be considered in this regard. The high prevalence of chronic bronchitis in England may well be a reflection of these circumstances.

to group adenocarcinoma together with terminal bronchiole carcinoma. We are continuing to study this problem. The data suggest that terminal bronchiole carcinoma is relatively more frequently seen in a nonsmoker than is epidermoid cancer. The adenocarcinoma patient is also more often a nonsmoker than the patient with squamous carcinoma, but we also find more heavy cigarette smoking among patients with adenocarcinoma than we find in the control population.

Weinhouse. Is chronic exposure to carbon monoxide a serious health problem? How often in general do serious toxic levels occur in cities? And is there a development of tolerance in chronic exposure?

Goldsmith. The use of the word "chronic" makes the first question more difficult to answer. In my opinion, exposure to carbon monoxide in cities is a health problem of some consequence. When you use the word "chronic," I believe you are suggesting a chronic carbon monoxide toxicity. This is a matter of dispute. My own view is that it has not been proved to exist. This should not be interpreted as meaning that it could not exist, and it should not be interpreted as meaning that it isn't worth looking for. But the evidence so far doesn't support it.

About serious toxic levels, my statements will refer to the standards set by the California State Health Department—the middle level, which is called "serious" because by definition it implies an important interference with the bodily function, in this case the function of transporting oxygen by hemoglobin. From reliable data, it may be stated that 30 parts per million exposure averaged over 8 hours will produce approximately 5 percent carboxyhemoglobin, which means that 5 percent of the body's circulating hemoglobin is unavailable for the transport of oxygen. According to this definition, such serious levels occur several times a year in Los Angeles. I don't recall the exact figures, but we checked statistics for 2 or 3 years and we found 14 such episodes. So I believe the California standards are satisfactory. Such levels do occur in cities,

as is indicated by samples from atmospheric monitoring stations. These are not samples taken within 2 feet of an exhaust pipe or in the immediate vicinity of traffic, but samples from stations reasonable and realistically located.

Finally, the question on tolerance is also unsettled, in my opinion. An interesting study by Gillick in England appeared to indicate that tolerance could develop.

I should like now to emphasize a point which has plagued much of our discussion today. And that is the importance of time—the time of exposure, the time of occurrence of response to exposure, the duration of exposure, the rate of change of exposure—all of these should be incorporated into experimental systems and into research programs. For example, I cite the work that Dr. Spicer reported. He talked about peak levels and mean levels. He did not talk about the rate of change of levels, and this is a parameter, so to speak, and a way of looking at air pollution exposures which may be a great deal more relevant than we have thought.

Also there was very little discussion on what is very important, to my way of thinking, the time relationship from all available data with respect to possible carcinogenic exposure. From all of the data that we already have, there is reason to believe that 10 to 30 years may elapse after exposures which have an effect on carcinogenesis before the carcinogenic result occurs. I want to make this plea to all who are engaged in research and to all who interpret research: pay a little more attention to the complexities introduced into research and its interpretation because of the factor of time.

Grace Talbott (for the San Francisco Bay Area Air Pollution Control District). Persons with chronic respiratory disease, especially those with emphysema, chronic breathlessness, chronic bronchitis, allergic asthma, or any other type of asthma, are victims of increased discomfort and disability when exposed to air pollutants. More specific research on pollutant irritants and their effects on the health of people who have chronic respiratory diseases should be developed by the combined effort of those separately involved in such research, and the results disseminated by the U.S. Public Health Service.

Francis Silver. Which straw really broke the camel's back is a foolish kind of question. I'm an engineer. Engineers deal with multiple causal conditions as a matter of routine, and even the thought of a single cause seems a little foolish. We quantify each of our various causes and stresses and summate them. I have been attempting for several years to do as the old-fashioned family physician or general practitioner used to, go into the home and make suggestions such as Dr. Randolph spoke of. And because of the increasing complexity of medicine he has to a considerable extent withdrawn from the home. In addition, the complexity of the home, engineeringwise and chemistrywise, has increased to such an extent that he is not able to cope with it. I have been attempting to go into the home as a graduate gas engineer and then study some of these environmental things and make recommendations to the housewife along the line that Dr. Randolph has made. I quite agree with him that these chemical conditions in the home are very grave and in many cases I think it would be more serious than either general air pollution in the outside air or smoking.

Now I shall read the question I sent in. Because of the nature of their work, gas and mining engineers have usually received very careful training in the direct evaluation of health effects in humans exposed to toxic gases. One of the basic principles that gas and mining experience over the centuries demonstrates is that effects such as can be observed in oneself and others in many of our city streets should form a basis for corrective action if serious chronic effects are to be avoided. Why is so little attention paid in air pollution work to such basic gas engineering and mining engineering principles, which have been established over centuries of experience? Present delaying practices in air pollution control seem to a gas engineer to be quite out of order. They seem similar to asking a structural engineer to use a safety factor so low as to insure that his bridge will collapse.

Sterner. Yes. Mr. Silver, I believe that, with respect to the more acute conditions, the principles of gas and mining engineering and of industrial hygiene can be applied and will be applied in the reasonably near future in establishing levels which are associated with overt evidence of injury. However, when we drop to a lower level, when we're concerned about chronic effects, the problem becomes infinitely more complicated. Look at the experience again in occupational exposures. Where a disease condition develops only after a long interval from the time of exposure, and from very small amounts of the etiologic agent, as for example the bladder tumors associated with betanaphthylamine, the problem of establishing with any reasonable

determining safe or permissible levels was even more difficult, so that many of the companies gave up the manufacture of betanaphthylamine, even though it was a very useful industrial chemical.

I should think then that, certainly with respect to the episodes of smog and of pollution which are associated with an increased incidence of clearly identifiable adverse health effects, we shall be able to come up—and I hope, in the not too distant future—with levels which will be realistic. I'm much more dubious that we shall get these levels with a reasonable degree of reliability for the long-term effects. Now this doesn't mean that I'm not in favor of doing something about air pollution anyway, because I think there is enough evidence to do something about it. But I think we shouldn't delude ourselves with the idea that we're doing this because there is clear and convincing evidence of serious and substantial injury to health. I think we have ample reasons to do it on other grounds.

E. J. Cassell. Dr. Spicer, both the British and the Americans smoke, but the British usually open doors and don't have central heating. And, although it's a little hot in our rooms, I'd rather have it that way than to have the doors open. I didn't really mean to be the last of a dozen people to comment on complexity, but perhaps the fact that many of us have so commented makes it appear that this in itself is as much a problem as the nature of the effects of air pollution. Dr. Spicer's paper and the work of Dr. Gocke at Seton Hall and our own work and that of many other people have shown that we can amass huge quantities of data which appear to relate to the people we're studying but which we're unable to relate well to the air pollution information which we also have gotten. I think it's harder to analyze data when you neither know what the cause is nor what effect you're looking for.

I also think that we have to begin to recognize for a change that the methods which we use to gather data may not be inadequate after all, that the data which we've gotten may be really quite good, that the pulmonary function data with all its imperfections may be really quite good, that illness data may be quite good, and that air pollution data with all its imperfections may be quite good, but that the methods for analysis are really totally inadequate. And that it's time we began to come together to discuss exclusively the best method of information obtained.

I also believe that Dr. Goldsmith's point about time is exactly pertinent to this, because that becomes one other factor which is impossible to incorporate under most methods of analysis. For example, if Dr. Kotin's relationship between influenza and carcinoma of the lung in mice were also true in human beings, then we should have about now the age-case ratio of cancer of the lung which we find in smokers who got influenza in 1918 to 1920, and about now we should be very distressed about it and start to do something about it. And pretty soon, the case rate would fall off as the susceptibles began to be used up and we would call this the effect of what we've done to the atmosphere, when in actuality it was only the effect of beginning to use up this particular set of susceptibles.

So, in summary, I think that we really have to begin to work consciously on much more sophisticated methods of analysis, methods that are the equal of the data we've obtained.

Spicer. Thank you, Dr. Cassell. Now, 15 seconds per panel member to answer one key question: Do you believe that air pollution is one of the causes of chronic respiratory disease? Dr. Goldsmith?

Goldsmith. Yes.

Spicer. Dr. Sterner?

Sterner. Yes; but if I modified it as I should like to, I'm afraid that I'd take more than my 15 seconds.

Spicer. Dr. Dohan?

Dohan. We discussed this last night and the question is what you mean by cause. But in a general way I would say yes.

Spicer. Dr. Kotin?

Kotin. I have nothing that would improve on Dr. Dohan's answer.

Spicer. Dr. Wynder?

Wynder. I would say that in special settings air pollution, as I indicated, can contribute to respiratory disease.

Spicer. Dr. Landsberg?

Landsberg. I pass.

Spicer. Dr. Mitchell?

Mitchell. I pass.

Spicer. Dr. Askew?

Askew. Both the individual and the community contribution of air pollution to chronic disease, I think, will grow and be self-evident in time.

CONCLUDING REMARKS

ROGER S. MITCHELL
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My personal interest in air pollution and its relation to human health has centered around the apparent part it plays in the pathogenesis of the chronic bronchitis-emphysema syndrome. Morphologic studies of 126 lungs, conducted at the Webb-Waring Institute for Medical Research in Denver, have shown that approximately 10 percent of our patients dying with clinical evidence of chronic obstructive airway disease and its complications have full-blown chronic bronchitis as the major cause of the clinical picture and death; the other 90 percent have sufficient alveolar wall destruction (i.e., emphysema) to explain their symptoms and death. In London, on the other hand, the findings are almost exactly the reverse (L. Reid): approximately 90 percent of a similar series of cases have enough chronic bronchitis but apparently not enough emphysema to kill them, and only about 10 percent have apparently died directly as a result of their emphysema.

This striking discrepancy can be explained, I believe, by the differences in the quality of the air in Colorado and in London. In London air, SO_2 has been quite prevalent, due to the English custom of burning soft coal in each family hearth instead of heating homes centrally. SO_2 is seldom found in U.S. air pollution, except in those areas where sulfur-containing coal is still burned in large quantities without proper safeguards.

SO_2, even in very low concentrations, temporarily paralyzes the cilia and thus probably increases the retention of all other pollutants (including cigarette smoke). Other factors, such as colder temperatures and higher humidity, probably play an additional part in explaining the difference in the autopsy findings between the United States and the United Kingdom.

I have also been interested in the relationship between the quantity of black pigment deposited and the amount of lung damage found in human lungs. Our studies have shown black pigment to be present in the lungs of some individuals as early as age 11, and in all individuals we have studied so far past the age of 25. The quantity of pigment varies roughly with the amount of alveolar wall damage, and its microscopic location is usually, but not always, immediately adjacent to the areas of damage. The quantity of pigment and damage could also be shown to have a rough relationship to the quantity of cigarette smoking; data on exposure to other air pollutants were too uncertain to be evaluated satisfactorily.

We have heard during this conference of a number of ways in which polluted air can cause human disease. It is by no means a simple picture. Multiple factors are almost certainly at work.

The most common pollutants are the relatively large particles—visible as smoke and usually malodorous; they are essentially without biologic activity. They can do harm, however, by overburdening the self-cleansing mechanisms of the tracheobronchial tree and thus tending to delay the excretion and prolong the adverse effects of pathogenic particles.

Next, we have the very tiny and usually biologically active particles—invisible and often without odor. SO_2 and NO_2 are the classic examples of this group. They can damage tissue acutely.

From experimental evidence not reviewed today (H. Boren), we know that the heavier, inert, and largely carbonaceous pollutants can probably also act as carriers of the smaller biologically active particles and thus may prolong and increase their adverse effects.

examples. Such substances have been shown to interfere with the essential enzyme processes of plants in remarkably tiny concentrations. Their effects on humans, however, other than irritative, are still poorly understood.

Finally, we also have noxious gases such as carbon monoxide. The prolonged inhalation of sublethal doses of carbon monoxide may not have a significant chronic adverse effect by itself, but in the presence of other noxious inhalants and especially for patients with chronic pulmonary or cardiac disease, the added effect of retained carbon monoxide may become significant. Lung tissue cells may well be damaged or killed by such combinations of noxious agents, when singly their effects are of no serious consequence.

It has been stressed that pollutants may be irritant, poisonous, or pathogenic; pathogenicity, of course, includes carcinogenic activity.

The importance of associated infection has been properly stressed. Polluted air has been found to contain an increased number of pathogenic microorganisms, and respiratory tissues, which are irritated and/or damaged by the inhalation of pollutants, are demonstrably more susceptible to both viral and bacterial infections. Chronic respiratory infection in turn makes the individual more susceptible to later exposure to the air pollutants.

In any discussion of air pollution and health, the problem of individual air pollution—tobacco smoking—should be included, as we have consistently heard this morning. Tobacco smoke contains numerous irritants, numerous carcinogens, and a poison, carbon monoxide. It also contains unidentified substances which, like SO_2, temporarily inhibit ciliary action. It is thus quite obvious that community and individual air pollution are effective partners in crime.

Armed with our present knowledge, I think we can construct a reasonably sound hypothesis regarding the pathogenesis of our two major chronic course, the causes of these two diseases are not yet fully understood, but we can be reasonably certain that more than one factor is involved in each disease.

First, perhaps, the self-cleansing mechanism is inhibited by SO_2, or by something in tobacco smoke and/or by the need to remove large quantities of inhaled inert carbonaceous material. Chronic irritation is caused by consequent excessive retention of various biologically active pollutants. Chronic irritation is frequently followed by chronic and/or recurrent infection. The respiratory mucosa is damaged, and this leads to deeper penetration of pathogenic substances, possibly prolonged in action by inert carbonaceous carriers.

In addition to this sequence of events, we are also almost surely dealing with differences in individual susceptibility as well as differences in degree of exposure to the pollutants. Individual differences probably include differences in susceptibility to infection, differences in hepatic function (as we heard today), or even inherent differences in the individual's self-cleansing mechanisms.

I have omitted reference to a host of other effects of air pollution, such as the influence upon the bronchospastic disorders, the influence upon the weather, and the influence upon the psychology of the population of a city.

In conclusion, it is my opinion that polluted air (from both community and individual sources) is one of the causes of at least two major respiratory diseases, bronchogenic carcinoma and the chronic bronchitis-emphysema syndrome. The complex mechanisms by which this happens are by no means clear. In spite of the inadequacy of our present knowledge, the available facts are, in my opinion, quite sufficient to justify an all-out campaign to control or eliminate air pollution throughout the United States. And last but not least, one distinctly possible and happy dividend of the abatement of community air pollution would be a probable decrease in the hazards of cigarette smoking.

Panel D

AGRICULTURAL, NATURAL RESOURCE, AND ECONOMIC CONSIDERATIONS

Chairman: JOHN T. MIDDLETON
Co-Chairman: IRVING MICHELSON
Reporter: ROBERT DAINES

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AIR CONSERVATION AND THE PROTECTION OF OUR NATURAL RESOURCES

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Importance of the Air Resource

Air is a mixture of gases, liquid droplets, and solid particles which envelops the earth's surface. The physical characteristics of air, such as temperature, water content, density, and movement in the lower atmosphere, influence growth and development of organisms and oblige man to adapt himself to his environment; they determine the success of the agriculturist and forester as well as the nature and extent of the earth's vegetation; and they affect commerce, industry, transportation, and urban development. The chemical composition of air directly affects man and the community in which he lives, the foods which nourish him, the forests which supply him with building materials and useful products, the lands which are an integral part of his economy, and the recreational areas which enrich his well-being. Air is a natural resource vital to man, essential for plants and animals, and necessary for many of man's community, domestic, and industrial activities. Man's dependence upon the air resource requires that it be protected from contamination and conserved for society.

Air is ever in a state of change. Not only do the physical but also the chemical characteristics of air change. Whereas natural forces bring about physical changes, alterations in air quality are principally due to pollution from man's activities. The discovery of smoke-marked wall paintings in caves in the south of France attest to the destruction of goods before recorded history. The Greek geographer Strabo wrote shortly before the birth of Christ of the irritating and offensive odor of the dye pits in the great Phoenician city of Tyre. Writings of the Middle Ages show that smoke from the burning of fuel caused soiling of property and reduction of visibility in many European cities. Industrialization in later centuries, and continuing today, is responsible for the emission of specific contaminants such as carbon monoxide, fluoride, sulfur dioxide, and radioactive wastes which are hazardous to man and damaging to property. The expanding growth of cities and the development of urban areas have created new forms of air pollution that are manifested by irritation to the senses, reduction in visibility, injury to vegetation and property, and the production of ozone and an array of other chemical compounds in the air space. Not all of the specific chemical compounds responsible for these manifestations have been identified, but it has been clearly shown that they result primarily from the oxidation of organic materials in the presence of nitrogen oxides in sunlight. These community and industrial contaminants affect the quality of the air resource itself; in turn, air quality affects other natural resources such as agriculture, forests, and lands.

Factors Affecting Nature and Extent of Air Pollution

The extent, severity, and character of manmade air pollution are determined by the kind, number, and location of contaminant sources, the chemical reactivity and interaction of the pollutants, the topography of the land, the weather, and the nature of the community.

The location of industries, such as aluminum, brick, ceramic, chemical, fertilizer, and glassworks, smelters, steel mills, and fuel-operated steam and electric powerplants, which release specific and injurious contaminants such as fluoride and sulfur dioxide, has a direct and significant bearing on the effect the pollutant will have on the value and economy of the area in which the industry is situ-

ated. The impact of such operations is greatest when the site is in the midst of a highly developed agricultural area enclosed in a valley bounded by barrier hills or mountains and subject to poor air ventilation or restricted air movement. Under these conditions, concentrations of as little as 0.5 part per billion fluoride or 0.5 part per million sulfur dioxide may persist long enough to damage agricultural crops, forage, and forests throughout the area and so adversely affect land values. The impact is least when the site is in open, undeveloped country without restrictive terrain and with maximum air movement. Under these conditions there is a rapid dilution of pollutants, and thus insignificant or no injury to vegetation, little damage to property, and no reduction in land value.

The effect of the polluted air resource upon vegetation and property is determined by the reaction time and rate of dispersion of the air mass as it moves within the airshed (*14*). The concentration of a relatively stable nonreactive contaminant, such as carbon monoxide, is highest at the point of origin and decreases with distance from the point of its injection into the atmosphere. Fluoride concentrations are likewise highest near their emission source and lowest away from it; whereas carbon monoxide levels decrease directly with distance and air movement, fluoride levels decrease more rapidly because gaseous fluoride reacts in air and is absorbed by vegetation, and particulate fluoride settles out. The amount of sulfur dioxide, like carbon monoxide and fluoride, also drops off with distance from its point of input and in accordance with rate of wind movement, but disappears somewhat more rapidly because of its uptake by plants and its greater reactivity in air, with the production of a variety of sulfur-containing compounds. The levels of nitrogen oxides and organic vapors diminish at a still greater rate as they quickly combine in sunlight to form compounds, such as ozone, peroxy-nitrates, and aldehydes, which characterize photochemical smog. The amounts of these several contaminants persist longer and are spread over greater distances when they are emitted from multiple pollution sources distributed throughout the community.

The specific nature of the organic components and the number and location of the nitrogen oxides emitters determines the formation and composition of photochemical air pollution. The saturated hydrocarbons from combustion of fuel, burning of wastes, or from direct vapor loss, generally are nonreactive or react slowly with nitrogen oxides upon irradiation, as do some other organics such as aldehydes, and produce delayed low yields of ozone and other products (*12*). Unsaturated hydrocarbons from whatever source react quickly upon irradiation with nitrogen oxides with the production of early high yields of ozone as well as some aldehydes and small amounts of other compounds, including the eye-irritant and plant damaging peroxy-nitrates (*17*). Motor vehicle exhaust emissions comprise a major source of these hydrocarbons (*5*). Although these hydrocarbons do react quickly, they nonetheless vary greatly in their rate of reaction so that some, such as 2-butene, react promptly upon emission, while 1-pentene and propylene react somewhat later, and ethylene still later. The different reaction rates for unsaturated hydrocarbons and the still slower reaction rates for saturated hydrocarbons and some other organic compounds result in the production of photochemical products of different kinds at different times and therefore at different geographic locations as the moving pollution cloud moves through the airshed (*16*). Since butene, pentene, and propylene produce peroxy-nitrates and ozone, while ethylene and most saturates produce ozone and no peroxy-nitrates, oxidant plant damage from about 0.1 part per million of the peroxy-nitrates would be expected in and about the immediate area of the principal contaminant emission sources and not at any distance from them. Very little plant injury from ozone will occur in the immediate vicinity of the principal emission source because much of the ozone reacts with residual organic wastes, and is thus removed from the atmosphere. Only ozone damage from about 0.1 part per million will occur away from the contaminant source because most of the organic wastes have previously reacted and only the slow reacting ozone-producing hydrocarbons remain.

The effects of this syndrome of varied reaction and decay rates are shown by the predominance of oxidant plant damage in Washington, D.C., and of ozone damage some distance away, with oxidant values ranging from 0.13 to 0.31 part per million in October 1961, and from 0.11 to 0.28 part per million in April and May 1962 (*15, 1*). Similarly, in Philadelphia, the principal emission source in that area, oxidant plant injury, is found, while ozone injury occurs in the upper Delaware River Valley as a result of the movement of the pollution cloud away from the metropolitan area and into the rural environs without much pollution addition

to the originally urban-formed cloud. While no oxidant values were available for Philadelphia, Pa., measurements taken at Trenton, N.J., ranged from 0.10 part per million in February 1960 to 0.20 in December 1960, with a total of 5 days in which values exceeded 0.15 part per million (*2*). The prevalence of oxidant injury throughout the Los Angeles airshed appears to be due to the more or less continuous injection of contaminants from the extended urban area into the moving cloud with the result that fractionation and the related effects observed in the discontinuous urban areas on the east coast do not occur.

Air quality standards have been established for several recognized contaminants of importance in California. The setting of these standards represents a pioneer effort to define air quality and provides a basis for maintaining and improving the quality of air over cities, farms, and forests throughout this large and varied State. A graded series of standards was set which describes the kind of pollutant and the amount and length of exposure which result in an effect upon man, property, and the air resource. The amounts and exposures which are likely to lead to untoward symptoms, irritation to the senses, damage to vegetation, and visibility impairment are given as "adverse" levels and presently comprise an oxidant index of 0.15 part per million for 1 hour, sulfur dioxide of 1.0 part per million for 1 hour or 0.3 part per million for 8 hours, and particulates in amounts to reduce visibility to less than 3 miles at a relative humidity of less than 70 percent (*4*).

The location of significant contaminant emitters is also important because the characteristics of a moving pollution cloud are affected by the nature of the pollutants added at various points along its route, and by the interaction and reaction rates of these contaminants. Since a fuel oil-operated steamplant producing 1 megawatt daily emits nitrogen oxides about equivalent to the daily emission of 786 motor vehicles, its geographic position significantly influences the characteristic of the photochemically polluted air mass. The location of these nitrogen oxide emitters along the coast in the path of the winds sweeping across the Los Angeles basin has a significant influence on the initial formation of photochemical air pollution. The location of nitrogen oxides emitters along the Delaware River also exerts a significant influence on the formation and character of the photochemical pollution ute to the initial formation of smog with upriver winds. Sources along the river not only add more nitrogen oxides and replenish a basic reactant but also alter the chemical composition of the pollution cloud through the fast reaction of nitric oxide with ozone and the consequent prompt concentration reduction of ozone in the cloud. The location of very large coal-operated electric powerplants in some rural areas of the southeastern United States away from urban centers is now believed to contribute to the production of ozone, which causes pine tree deterioration and reduction in value of forest products.

The relatively higher levels of sulfur dioxide on the eastern seaboard contribute to the relatively greater amount of visibility reduction in New York and the Delaware River Valley than occurs in California. The addition of significant amounts of sulfur dioxide to urban air results in its reaction with organics in sunlight to form other compounds and liquid droplets which interfere with visibility. Visibility is further reduced as the sulfur dioxide participates in the nitrogen oxides and hydrocarbon photolysis to produce still more liquid droplets and still further to reduce visibility.

Protection of the Air Resource

Since the dispersion of polluted air is a function of wind movement and topography, the effect of source contamination can sometimes be minimized through appropriate site location (*19, 3*). Air, however, can do no more than disperse contaminants. Since the number of pollution sources is constantly increasing, and at a rate greater than the increase in population, air pollution abatement requires control at the source. Pollution from electric power development can be reduced by improved fuel combustion, the use of fuel such as natural gas, which produces low levels of pollution per unit of energy developed, and particularly by the production of power by hydroelectric generators. The air pollution potential of the very large and significant motor vehicle exhaust gases can be altered but not appreciably reduced by controlling the composition of the fuel, since the intensity of pollution remains in large measure a function of exhaust concentration rather than fuel composition (*10*). Since no hydrocarbon fuel has been found that does not produce some manifestations of photochemical air pollution, it becomes essential to re-

effected through the development of community mass transportation systems. Abatement of specific contaminants from industrial sources, such as fluoride and sulfur dioxide, requires process control and collection of waste effluents.

The efficacy of these control methods decreases with an ever-increasing population growth and urbanization. Effects of single-source pollutant emissions have been detected in many and varied areas throughout the United States. Manifestations of photochemical air pollution, including oxidant index, plant damage, and rubber cracking, have now been seen and reported in urban and adjacent rural areas in 27 States, the District of Columbia, Canada, and Mexico, as listed in table 1 and shown in figure 1. In California, air pollution has been reported affecting 26 of the State's 58 counties, as shown in figure 2. While the principal effect of air pollution has been in urban areas where the intensity and frequency of air pollution attacks continue to increase, there has been increasing evidence of its intrusion in nonurban residential, agricultural, and recreational areas. This is well during 6 months of 1961 and but one day in 1960, and with the occurrence of 52 days above the adverse level in Fresno in 1961 and no forecast from the sampling taken since 1957 that this ever would occur (*6*).

As population and urbanization of the country increase, there is a concomitant increase in air pollution resulting from domestic and industrial growth. Likewise there is an increase in demands made upon the limited air resource.

The need for air of good quality becomes acute when communities begin to fill up the floor of an airshed and throw out wastes into the air at a rate exceeding the rate of air replacement within the airshed. The situation becomes serious when the flowing air mass arriving at a relatively smaller community is already laden with contaminants to such a level that a comparatively small addition of atmospheric waste replenishes the supply of reactive contaminants; the air mass is then no longer effective in dispersing and diluting wastes but dutifully continues to transport them from area to area within the airshed.

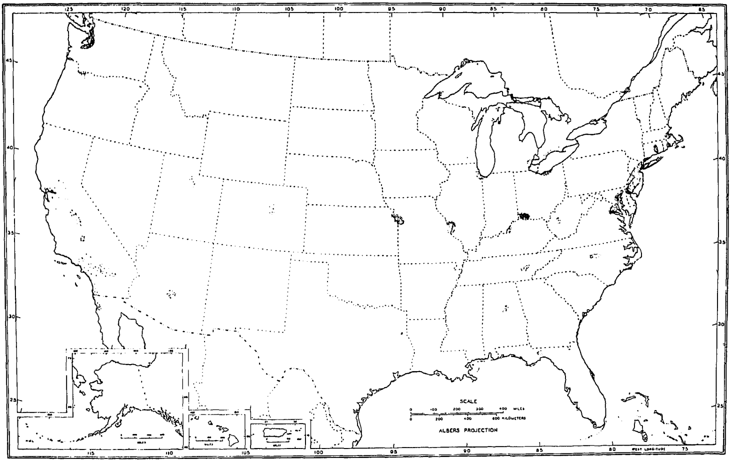

Figure 1

Photochemical air pollution in Canada, Mexico, and the United States occurs in the shaded areas

TABLE 1.—*The occurrence of photochemical air pollution in North America*

Area affected	Photochemical manifestation		
	Oxidant index	Plant damage	Rubber cracking
Alabama	+	....	....
Arizona	+	+	+
California	+	+	+
Colorado	....	+	+
Connecticut	....	+	+
Delaware	....	+	+
District of Columbia	+	+	+
Florida	....	+	....
Hawaii	+	+	+
Illinois	....	+	+
Indiana	+	....	....
Kansas	....	+	....
Kentucky	+	....	+
Maryland	+	+	+
Massachusetts	....	+	+
Michigan	....	....	+
Missouri	+	+	+
New Jersey	+	+	+
New York	....	+	+
North Carolina	....	+	....
Ohio	+	+	+
Oregon	....	+	+
Pennsylvania	+	+	+
Tennessee	....	+	+
Utah	+	+	+
Virginia	....	+	+
Washington	....	+	+
West Virginia	+	+	....
Canada	+	+	+
Mexico	+	+	+

The airsheds, or atmospheric basins, which form the boundaries for the polluted air mass generally conform to the natural watersheds. The topographic boundaries, the windflow pattern and rate of movement, together with the containing ceiling of the warm inversion layer, limit the amount of air available to most communities and the valuable land, agriculture, and recreational resource. The principal airsheds of California have been described and illustrated and are reproduced in figure 3 (*13*). The areas in California affected by photochemical air pollution all occur within these airsheds as shown by the overlay of affected areas upon airsheds given in figure 4. The lightly shaded zones of the airshed are the areas with an air pollution potential and may be designated as sites requiring regional air pollution control programs designed to prevent the further encroachment of the pollution cloud within the atmospheric basin. Pollution now occurs in all but one of California's principal airsheds, suggesting that concerted efforts and new approaches be used to prevent or delay the soiling of the atmosphere in the Monterey airshed.

Figure 2

Photochemical air pollution and plant damage occurs in the shaded areas distributed in 26 of California's 58 counties

These several considerations suggest that it is necessary in planning community development to take cognizance of the relationship between the air resource and the community needs for commercial and industrial development, energy production, fuel usage and transportation, agriculture, and forest and recreation land. Adequate air conservation depends upon total community planning and, because the quality of air affects both the nation's natural resources and its economy, it is important that the protection of the air resource be placed in the hands of a team of trained minds in the several disciplines concerned. Further, because air pollution has characteristics common to many cities, counties, and States, it is important that there be a national effort to develop acceptable air quality standards, a national effort to control motor-vehicle-created air pollution, and strong Federal leadership to develop an effective national air conservation program.

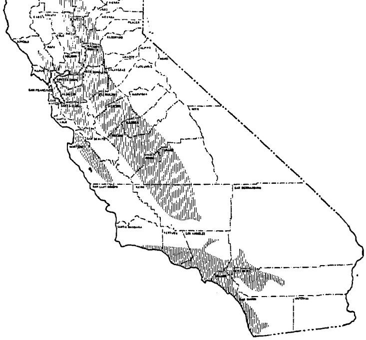

Figure 3

The five principal airsheds in California are shaded and are designated as (1) South Coast, (2) Monterey, (3) Central Coast, and contiguous (4) Sacramento and (5) San Joaquin

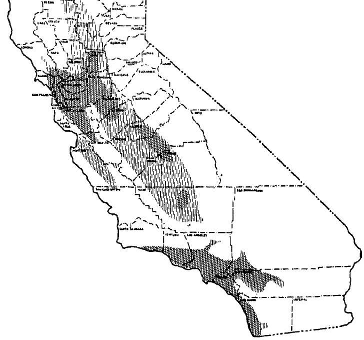

Figure 4

The presence of photochemical air pollution (diagonal shading) within the principal California airsheds (vertical shading) is shown by cross-hatched shading

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[illegible] AIR CONSERVATION AND THE PROTECTION OF OUR NATURAL RESOURCES

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Dr. Middleton has emphasized two aspects of control of air pollution. One is the control at the source and the other is the control through proper planning in the development of the community. Living as I do in a smog-plagued city, I could not agree more with him. Source control has been exercised in Los Angeles on stationary sources so effectively that smoke and fumes are no longer a serious problem. Through this control real estate values have been increased and housing developments are now seen in formerly desolate uninhabitable areas.

Because of this improved situation, however, a new set of complaints develop from people who have moved to within a short distance from the pollution source. Some of these people may be grateful for control, which made it possible to settle in the new development; to most, the fact stands out that there are still pollutants released and they will not rest until new and more efficient controls have been applied. This points to one of the fundamental laws of air pollution abatement, that control is always a balance between the desire to obtain as clear air as possible and the price the community is willing to pay for reaching this goal.

Theoretically any amount of control can be accomplished. In practice, this would be prohibitive because the engineering cost rises steeply with increased control efficiency and would soon exceed the value of the products made. A balance has to be found, whereby the air is reasonably inoffensive while at the same time the control cost allows normal economic development and activities to continue. In modern concepts of air pollution control, the consideration of what are acceptable levels of pollution for a community comes first. After this has been established attempts can then be made to come as close to these levels as engineering methods and economic factors allow.

The adoption of community air quality standards by the Department of Public Health of the State of California is therefore one of the most significant steps in air pollution control in recent years. The adverse levels warn a community that when these are exceeded undesirable symptoms or discomfort may result. It is recognized that the present levels are based on insufficient evidence and that more thorough studies are needed to take into account combined actions of pollutants and the presence of particulate matter. Extrapolation from animal experiments will give some indication of the toxic effects of pollutants on humans; for more accurate information on those effects, however, actual observation of humans will be necessary. A community standard should be a level below which physiological reactions are reversible and which are within the normal variations of body functions. The program of determining the tolerance to foreign materials in the air is a difficult and long-range one and requires proper planning. For leadership in the proper coordination of efforts in this direction we look to the U.S. Public Health Service.

While we would like to have more thoroughly established health standards, the provisional standards for California had to be used to calculate the control needed in Los Angeles to reduce the smog conditions to a lower and more acceptable frequency and severity. Apparently an 80 percent reduction of the emission of hydrocarbons is needed to reach the 1940 no-smog level. Devices for crankcase fumes are available which accomplish

this; unfortunately, this is not the case for control of the engine exhaust. At present there is no afterburner which will accomplish an average emission necessary to have an 80 percent reduction. Under test conditions they may meet about 70 percent control; however, a communitywide application of such devices will remain far from the theoretical goal. Moreover the premise upon which the control calculations were based assumes that there is no increase in other smog components such as oxides of nitrogen. The steady increase of these combustion products will offset the reduction in hydrocarbons. Also the presence of sources of hydrocarbons and oxides of nitrogen other than motor vehicles, amounting to about one-third of the total basin emission, detracts further from the effectiveness of the control effort.

While it may be necessary to accept the limited control during the early phases of smog abatement, it is essential that strong emphasis is placed on engineering research leading to higher and higher efficiency of the control methods. This is true for motor vehicle control as well as for the more classical problems of dust and fumes. I mention the difficulties in coping with the relentless growth of the communities and their effluents to stress another point which Dr. Middleton brought up; that is the contribution which the community can make by proper planning of its expansions. This involves the development of adequate transportation and parking facilities, zoning of industry, breathing spaces in the form of recreation areas, and many other methods of control dictated by local conditions and opportunities. Many of these indirect controls of air pollution are an asset to the community and have a permanent value for better living.

Although in the State of California motor vehicle control has been brought under State control, it is still the responsibility of local communities to keep their air fit to breathe by whatever means is most suitable—be it direct or indirect control, or a combination of both.

All those engaged in air pollution problems of the magnitude created by our expanding cities have become aware that a broader view has to be taken of the air pollution complex and that smog is only one facet of this complex. Housing, transport, health, and water and air problems are all interrelated, and a diagnosis of the total situation should be made, by trained minds in the several disciplines concerned, as Dr. Middleton suggests.

Uncontrolled growth was all right when there was more room. With a few hundred thousand people migrating yearly to the city, planning has become vital if we want to retain the optimum conditions of living. Such a broad approach needs imaginative leadership in our government but it also needs the enlightened support of the citizens to overcome inertia and wishful thinking.

The idea of an all-out attack on the smog problem is not new. It was well characterized by Dr. Weidlein of the Mellon Institute in a paper presented before the Pittsburgh Chamber of Commerce describing how his town got started on the road to solving its air pollution problem.

For years Pittsburgh had suffered, but no matter what meetings were held or regulations adopted, its landmark, the Cathedral of Learning, became blacker and blacker. Finally the people of this unhappy town decided one day that they had breathed enough soot. All branches of community life, civic organizations of all kinds, government, labor organizations, army, and church united in a council which had but one goal, namely to see that Pittsburgh was cleaned up. It is from the leader of this organization that I quote:

> The story of the smog nuisance is the old and oft told story which runs through the history of American municipalities. It is the story of rapid growth in population and industrial activity, marked by wastefulness of material resources, carelessness in regard to the future, indifference to many things of life, and a blind opposition toward anything which seems to threaten in even a remote way that which is termed prosperity.

After describing the successful completion of his monumental task he concludes with justified pride:

> Air pollution control in a modern city and in a mature city is built on a fresh concept of people living together in productive enterprise rewarded in terms of work and enjoyment. The council of the people does not impose, it unites.

These are words of wisdom from a great statesman. They apply to the soot problem in Pittsburgh and to smog control in Los Angeles, but more than that, they are an inspiration to all who are concerned with community problems. We need a willingness on the part of people to forgo some short-term profits in order to gain the far greater benefits of better living conditions for all. To reach this goal we need a united approach by civic groups and government at all levels to give the leadership necessary to carry out a well-designed plan of action which will give us the clean air that we all want.

EFFECTS OF AIR POLLUTION ON CROPS AND LIVESTOCK

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I am honored to share a place on the program with some of the distinguished pioneers in the field of air pollution research. Much of what I have to say reflects their contributions to our knowledge.

Then, too, I am glad to have this opportunity to focus attention on what I believe is an increasingly serious hazard to the Nation's agriculture.

We already know that air pollution is costly to farmers. There's good reason to suspect that it's even more costly than we know. And every indication is that it's going to get worse as this country continues to grow.

The point I want to make is that anything that increases farmers' costs is important to you and me and 187 million other Americans. Our highly developed economy is based on our remarkably efficient agriculture.

Air pollution is not a new problem in agriculture. But we are just beginning to appreciate the full significance of this threat. Most of the old pollutants are still causing some trouble, and we have new ones that promise to challenge our finest scientific brains.

Let's look at today's major problems.

One of the oldest known pollutants of rural air is sulfur dioxide. Its effects on plants have been recognized for well-nigh a hundred years.

Fortunately, sulfur dioxide is no longer killing vegetation on as grand a scale as it was early in this century around the great copper smelters at Anaconda, Mont., and Ducktown, Tenn. Their fumes drifted for miles and left gullied deserts, bare to the grass roots. Control measures have now done away with such extreme damage.

And yet, we still find some crops and trees being killed and others being marked by sulfur dioxide from a host of sources all over the country. These include power, chemical, and steel plants, as well as smelters.

Of a wide variety of plants damaged by sulfur dioxide, the most sensitive are alfalfa, barley, cotton, and coniferous trees. This gas may still be a serious factor in some forest diseases. Recent work on the cause of post-emergence acute tip burn in Tennessee indicates that sulfur dioxide may be involved as a possible factor in this disease.

Another important nationwide air pollution problem is the damage to vegetation and livestock from fluorides, which are thrown off in the course of heating to extremely high temperatures, ores, clays, or fluxes containing fluorine.

The fluoride sources that caused trouble with cattle 15 to 20 years ago are now reasonably well under control. Many of these—steelmills, ceramic works, aluminum reduction plants, and superphosphate factories—have installed air-cleansing devices on their flues and furnaces.

Even so, the number of fluoride sources has increased, and we see the effects in several places.

Ponderosa pine has been extensively damaged by fluorides from an aluminum plant in Spokane County, Wash. Citrus trees are adversely affected in California. Many other plants are sensitive, particularly gladiolus, apricot, sweet potato, grape, and prune.

But even more troublesome is the fact that some of our common forage plants are fairly resistant to fluoride injury. Alfalfa, for example, may go on

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storing atmospheric fluoride and still look perfectly normal; yet it may contain enough of this toxicant to produce a serious case of fluorosis in animals that eat the hay.

A serious new air pollution threat has developed in the last few decades. This new pollutant—photochemical smog—is no longer a problem of the Los Angeles basin alone. It is causing significant crop losses along the northeast seaboard, and its markings have now been found in practically every metropolitan area from coast to coast.

Whereas fluorides and sulfur dioxide are usually traceable to a few large industrial plants, smog comes from millions of sources throughout our highly industrialized and mechanized society.

In our dirty urban air are many waste materials. Among them we find nitrogen oxides, produced wherever hot combustion takes place, such as open fires, home furnaces, and automobiles. And we also find incompletely burned hydrocarbons thrown off from all types of combustion; at least 400 different hydrocarbons are found in gasoline alone. These contaminants are often entrapped close to the ground by an inversion layer of warm air, a typical weather pattern in the Los Angeles basin as well as over a vast area of the northeast.

When hydrocarbons and nitrogen oxides mix in the atmosphere in the presence of sunlight's ultraviolet rays, some complex and delicately balanced reactions take place. This is the source of two oxidizing substances that cause most of the so-called smog damage to plants.

One of these oxidants is ozone, which primarily injures the upper surface of plant leaves. Some ozone occurs naturally in the atmosphere, but ordinarily not in harmful amounts.

The other oxidant is peroxyacetyl nitrate, or PAN, which causes a silvering, glazing, or bronzing on the lower surface of the leaves.

It takes only fractions of a part per million of either of these oxidants to damage some vegetation. This may mean not only marking the plants but also reducing photosynthesis, increasing respiration, inducing early leaf drop, slowing growth, and lowering yield.

Ozone has now been definitely identified as the cause of weather fleck, a disorder that injures the leaves of tobacco all the way from Florida to Canada. In New Jersey, ozone has damaged spinach extensively; indeed, spinach can no longer be grown in some areas. Grape, beans, and a number of ornamentals have been injured, and the list of damaged crops continues to lengthen.

The so-called mystery disease of eastern white pine, emergence tipburn, was recently attributed to ozone. This blight kills and damages trees wherever eastern white pine grows. Ozone also appears to cause X-disease, a chlorotic decline striking thousands of acres of ponderosa pine in California's San Bernardino Range.

While ozone appears to be responsible for most of the smog damage in the East, PAN is considerably more destructive in Southern California. I understand the threat is beginning to spread into the San Joaquin Valley, where 5 of the Nation's 10 leading farm counties are located. PAN injury is seen on many field and horticultural crops.

As this brief review indicates, a number of air pollutants are damaging the crops, forests, and livestock of this country. How well are we prepared to deal with these toxicants? How much do we know about them?

In the case of livestock, our main concerns have been an old problem of arsenic poison from smelters . . . and the ever-present fluorides. We are well aware of the lethal effects when animals ingest forage plants that absorb these pollutants.

Beyond this point, however, we have little to go on. There is some reason to believe that such pollutants could derange the growth processes of plants and thus reduce the content of desired feed nutrients or cause the formation of toxic constituents. But this area has barely been explored.

At present, we have no solid evidence that farm animals are significantly injured by such pollutants as sulfur dioxide or oxidants. Very little work has been done on toxicity levels for livestock.

And yet, medical research reveals that these toxicants do present a hazard to human health. Absorption and circulation of such gaseous compounds can damage tissues beyond the lungs, for example, enzyme and nervous systems, blood hemoglobin, and organs such as the liver and kidneys.

In view of the dangers to man, it seems reasonable to think that there must be many areas where livestock are endangered. Substantial losses could occur in borderline zones where the effects don't look spectacular but pull down performance in terms of reproduction, growth, and output of milk, eggs, and wool.

Turning to plants, we find that we know a little more about the effects of air pollution. At least, the visible effects of most of the common toxicants

induce on plant leaves. And the injury patterns produced by ozone and PAN are not difficult to distinguish. Workers also have considerable knowledge of the breakdown that takes place within the cell structure of the leaves.

But we are not so well off when it comes to the possible effects of air pollutants on such matters as the growth, yield, nutritional quality, and survival of plants. We have some leads, or course. We know that severe leaf injuries by pollutants will affect growth, and perhaps survival in the case of trees, which take repeated exposures year after year. We have reasonable evidence that oxidants or fluorides, even at levels that don't mark the foliage, may significantly reduce growth rate and fruit quality in some cases.

But this area is complicated by two extremely important influences, genetics and environment. As for genetics, we expect different species to respond differently to air pollution, but the variations within species are often just as great. Workers have seen the effects of many environmental factors, including rainfall, temperature, wind, nutrition, soil moisture, and management practices. For example, there are significant differences in the injury threshold from one area to another; much less oxidant is required to damage plants in the humid East than in the arid West.

On top of all this, the pollutants themselves interact with each other in the atmosphere and also interfere with each other's effects within the plant.

You can see that we have explored the effects of air pollution on crops, but so far we haven't pushed in deeply on a broad front.

It's not surprising—considering how little we know about these effects—that we can't say exactly how much the losses run to in this country.

Of course, the answer is easy in the case of a crop like romaine lettuce, which sells on the basis of appearance. Ozone markings on the outer leaves could make the crop a total loss.

The question is more difficult when a crop like alfalfa is injured by sulfur dioxide. We now know that yield is reduced in proportion to the area of leaf destroyed, whether destroyed by clipping or by air pollution.

But we face a far more complicated problem in determining PAN damage to a citrus tree. As yet, no one can say how much yield or grade of fruit how much this will affect the crops that follow.

And the answer is still harder to find in the case of fluoride damage to pine trees. Here we are dealing with a crop that may not be ready to harvest for another 40 or 50 years.

Although we don't have a good measure of the total national loss from air pollution, figures have been published for some localities. In Southern California, for example, losses of vegetation due to oxidants are thought to be around $10 million a year. This includes only the readily demonstrated losses of vegetable crops downgraded because of markings or left unpicked in the field.

If we try to add up all the known losses around the country, make some reasonable estimates for the suspected losses due to reduced yield and quality, and include a guess for losses in ornamentals, the figure is in the hundreds of millions of dollars a year.

It's apparent that agriculture has a vital interest in air pollution, and a responsibility for research in this field.

Some very good work is already being done. The pioneering research of the University of California and the U.S. Public Health Service immediately comes to mind. Several State experiment stations, including those in Tennessee, New Jersey, and Connecticut, have studies underway. Industry and private institutions are conducting and supporting research.

Right here, I want to make it clear that I am not satisfied with the meager efforts in this field by the U.S. Department of Agriculture. But those of us who are responsible for the Department's research do recognize the importance of this problem. And I am more hopeful now than I have been in several years that we will eventually obtain support at the level we feel is justified.

All the work now underway—good as it is—adds up to little more than a beginning on the problem of air pollution in agriculture.

I feel that the greatest need, in connection with air pollution's effects on crops, forests, and livestock, is basic research. We need to determine the mechanism of action of pollutants and their effects on metabolic processes. Such work is essential if we are to evaluate the effects on growth, development, and survival of plants and animals, as well as on the quality and use of the products.

An example of the sort of work I have in mind is the project the University of California at Riverside is now carrying out under contract with the U.S. Department of Agriculture to determine the effects of air pollutants on carbohydrate metabolism in citrus. We hope to learn for the first time how pollutants influence the foodmaking process and enzyme activity.

Basic studies should be conducted with plants and animals to discover how their physiological response to toxicants is related to the influences of genetics and environment. This basic work should include the effects of intermittent exposures of forest trees to low levels of air pollutants over a long period.

There is also need for research on the nature of the pollutants, on levels of toxicity, and on how the nutrients and quality of feed are affected. We should find out the extent to which agriculture itself contributes to air pollution, as in the burning of straw and stubble. Adequate surveys must be conducted to assess the damage to crops and livestock. Additional work is needed on biological indicator plants that reveal the nature as well as the presence of air pollutants.

From investigations such as I have suggested, we should gain the knowledge that will enable us to deal with air pollution in agriculture. Let me suggest some of the possibilities.

One is the development of protective management practices. For example, we might be able to control weather fleck by applying antioxidants to tobacco when an ozone buildup is expected. Workers in New Jersey see the prospect of a forecasting system to warn farmers, greenhouse operators, and homeowners of air pollution threats. The Weather Bureau now has a pilot-type forecasting service for the eastern half of the country.

A second possibility is the development of resistant varieties and strains. Breeders recognize that plants vary in susceptibility, and this knowledge is already being put to use. In the Connecticut Valley, for instance, resistant varieties of tobacco are greatly minimizing damage from weather fleck.

A third possibility, one that I regard as a matter of great urgency, is the development of air quality standards. It is quite evident from the recent buildup of pollution in California and along the East Coast that standards have to be established. And in many cases, the limit of a standard is going to depend on the vegetation desired for an area, whether for economic agriculture, for the maintenance of a cover to prevent erosion, or for the growth of ornamentals for esthetic purposes.

A fourth possibility for using new knowledge of agricultural air pollution is the development of better Federal consulting services to States and local communities. We should be in far stronger position than we are to furnish advice on such matters as gauging the effects of pollutants, conducting surveys, formulating air quality standards, and devising field control practices.

I recognize that finding the answers we need on air pollution will not be simple, quick, or cheap.

For one thing, it will take improved research tools. We must have better instrumentation for continuous monitoring of pollutants at low levels. Some of our present processes are too tedious and expensive, and there's not enough equipment available.

Even more important than tools, however, is well-trained personnel. Exploration of this area is complex, and it calls for competent workers in many disciplines—pathologists, physiologists, veterinarians, nutritionists, agronomists, horticulturists, foresters, meteorologists, and engineers, as well as analytical, physical, and biological chemists. It won't be easy to find enough of the kind of people we need to do this job.

So we shall be up against some formidable obstacles as we move ahead against agricultural air pollution. But we must not allow these obstacles to keep us from launching a full-scale research effort as soon as possible. The kind of work that is needed will take time.

I am convinced that air pollution is not so much today's problem as it is tomorrow's. We may well have 14 percent more people and 26 percent more automobiles in this country by 1970. There's every reason to believe that the trend toward greater urbanization and greater mixing of agricultural and industrial areas will increase the total impact of air pollution on the Nation's farms.

We must face the fact that our air—like our land and water—is limited. It, too, will have to be conserved.

I believe it is vital that air-pollution research in the field of agriculture moves ahead—now—before we get even further behind.

Prepared Discussion: EFFECTS OF AIR POLLUTION ON CROPS AND LIVESTOCK

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Dr. Rodenhiser has presented an excellent review of air pollution and the problems that it is creating for those engaged in agricultural pursuits. In addition he has pointed out areas where additional information is badly needed to properly evaluate the complex effects of pollutants on growth, yield, quality, and survival of plants. Our previous speaker has wisely stressed the need for basic developments on a wide front, if the mounting air pollution problems are to be met successfully. While agreeing completely with the research needs that have been outlined, I would like to suggest some additional areas where some information and improved equipment are of real concern to us in New Jersey.

(1) We need improved instruments for measuring pollutant levels in the atmosphere. A good example of this need is apparent to all who have tried to determine ozone levels in metropolitan areas where other oxidants and SO_2 are common contaminants. The whole problem of atmospheric sampling and instrumentation needs improvement.

(2) A tremendously important problem area involves a more thorough understanding of the photochemical reactions occurring in the atmosphere. Some needed information is suggested by the following questions.

a. A most important consideration in the area of preventing damage to vegetation from ozone—would the use of blowby and catalytic mufflers on cars (if they prove to be successful) alter the ozone concentrations in the atmosphere? Would the use of such devices aid in the prevention of plant damage, or would they only tend to increase the relative importance of ozone in the pollution complex?

b. Dr. Middleton has presented an excellent statement on chemical changes in an aging pollution cloud. This statement provides information on a question that I included in my report as an area where more information is badly needed. I prepared this statement before knowing of the subject matter to be treated by our chairman. The problem in question is "Why is ozone damage to vegetation of such importance in the East, while such damage is relatively less important in the West; and why is PAN injury relatively more important in the West than in the East?" I would like to make a few observations that agree in principle but may differ a little in detail from Dr. Middleton's report.

As I understand Dr. Middleton's report, during the early life of a pollution cloud, PAN and ozone are produced by the degradation of unsaturated hydrocarbons. As the cloud ages, the more stable or saturated compounds are decomposed with the continued development of ozone but with little or no PAN occurring. Hence, the older cloud will be richer in ozone and leaner in PAN than would be the case of a cloud containing general city pollutants near their point of origin. The reason for the predominance of ozone injury in the East, according to this theory, lies with our discontinuous population distribution, thus providing pollutants in our limited rural areas that result from the degradation of hydrocarbons that characterize an aged cloud,

FIGURE 1

Characteristic "flecking" (stipple injury) of the upper surface of middle-aged fully expanded tobacco leaves caused by ozone.

since the unsaturated compounds would have been decomposed by the time the pollutants reach the rural area.

Concerning the situation in the Northeast, I would add these few thoughts to the ones expressed by our chairman. In the East, we often have periods of relative calm lasting through the night hours and continuing until 9, 10, or 11 o'clock in the morning. Often these calm periods are accompanied by more or less atmospheric stability. This period of low ground winds is followed by increased wind velocity and a less stable atmosphere. In other words, we experience many days during our plant growing season when pollutants from our cities may be transported at night into our limited rural areas before they are exposed to the ultraviolet light of the sun's rays. This, then, essentially gives us a continuous rather than a discontinuous population distribution at least for a portion of the time when meteorological conditions would favor elevated pollution concentrations. Perhaps this is why both PAN and ozone injury symptoms often occur together in New Jersey. This may also explair how severe PAN-type injury occasionally occurs 3(or more miles out in the rural areas to the southwest of Philadelphia.

There are two other factors in addition to th(prolonged periods of atmospheric stability whicl characterize the Los Angeles area, which differ be tween East and West and which may be very sig nificant in the pollution picture in each area. Th first is the difference in the type of fuels used in th two regions, and the second is the difference in pre vailing atmospheric humidity.

In the East, we consume relatively larger quar tities of coal and fuel oil to produce heat and er ergy than is the case in the West. This would b especially true during many night hours when aut travel is at a minimum. While I have no data t present, I would expect that volatile organics, r(sulting from the consumption of coal and fuel oi would be characterized chiefly by saturated con

FIGURE 2

White "stipple"-like injury to swiss chard leaves causec an exposure to ozone.

pounds, whereas automobile fuels would have a higher content of unsaturated hydrocarbons.

In addition, in the East relative humidity is often high during the plant growing period. Leighton points out in his "Photochemistry of Air Pollution" that photochemical reactions occurring in the atmosphere are a continual process of generation and degeneration of compounds. He also states that the photodecomposition of ozone in ultraviolet light in the absence of water vapor generates a maximum quantum yield of 6.7; whereas in the presence of water vapor, yields as high as 130 may occur. This suggests that water vapor engenders the production of more energetic products in ozone photodecomposition than is the case when dry ozone is involved. The extent to which water vapor may affect other reactions occurring in the atmosphere is probably unknown; however, it may be that this in some way contributes to the differences that occur between East and West.

And then, as a last comment, I wonder if the differences between pollutants in the two regions are really as great as we may think. I wonder if ozone would really be emphasized so much in the East if it were not for the very ozone-sensitive tobacco crop. I rather expect that if tobacco were not grown in the East we would consider ozone and PAN to be about equally important as phytotoxic pollutants. We have listed 29 plant species that are occasionally injured by ozone and about an equal number that occasionally show PAN-like injury symptoms in New Jersey.

FIGURE 3

Ozone injury to corn appearing as necrotic streaks on the leaves. The older leaves of young sweetcorn plants seem to be most susceptible.

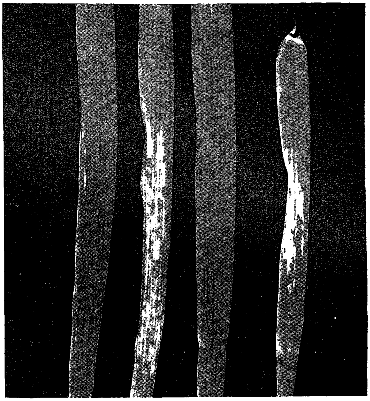

FIGURE 4

Ozone injury to (small grains) oats appearing as necrotic streaks on the leaves. Where injury is severe, these streaks coalesce, producing necrotic areas that may be rather extensive.

We have heard much about the occurrence in southern California of silver leaf, now identified as PAN injury. This type of injury has exacted a heavy toll on many species of plants in the Los Angeles area and in recent years has been recognized as a cause for concern in other metropolitan areas. Ozone was not considered to be of economic concern as a phytotoxicant until Richards et al. in 1958 established ozone as the cause of grape stipple in California vineyards. The next year Heggstead et al. reported "weather fleck" of tobacco, a rather common problem in eastern tobacco fields, as being due to ozone toxicity. That same year Daines and associates reported that ozone was a phytotoxicant of major importance in New Jersey affecting at least 12 species of plants. Since then this number has been extended to include at least 29 species.

Since the recognition of ozone injury to vegetation is so new perhaps some comments in this area would be of value.

The type of fleck injury observed on tobacco has been observed and reproduced on many plant species, including swiss chard, cucumber, spinach, turnip, mustard, carrot, radish, onion, parsley, wa-

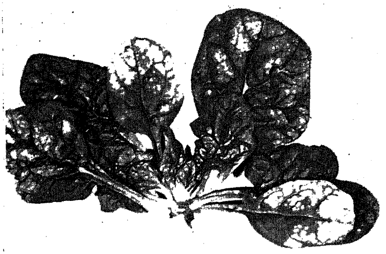

FIGURE 5

Ozone injury to spinach expressed in the field as "milk white" necrotic spots. These spots may show upper surface glazing and they appear on the middle-aged fully expanded leaves of older plants or on the cotyledons or older leaves of young plants. Young plants (cotyledon to 8 or 10 leaf stage) seem to be the most susceptible.

termelon, squash, tomato, cantaloup, sunflower, sweet pea, escarolle, chicory, endive, and chickweed. A fleck accompanied by a black pigment, a symptom described as stipple of grape, has been observed and reproduced not only on grape but also on white potato and bean. Examination of cross sections of these ozone-injured leaves indicated that the palisade cells were characteristically disorganized. Only in cases of severe injury wa the spongy parenchyma of the mesophyll disruptec In the field, cereal crops have frequently exhibite necrotic spots or streaks on the leaves which coul be attributed to ozone. Since these plants do nc possess palisade cells, perhaps it is not surprisir to find the streaks appearing similarly on both tł upper and lower surfaces. These streaks occur : the well-aerated tissue between veins. In additio evidence is strong that a white pine tip burn ozone inspired. In addition, a number of plar typically develop milk white spots of varying si as a result of ozone toxicity. Some such plar are spinach, alfalfa, clover, radish, turnip, tomat cucumber, petunia, etc. On spinach these wh: necrotic areas may be accompanied by a glazi: of the upper surface. In our field surveys we ha observed that when oxidant type (ozone and PAI air pollution injury occurs, the vegetation in seve: counties may be affected.

Yes, air pollutants of the oxidant type are ca ing increasing concern in many areas and t mounting problems can only be met successfu by increased support for research. This is es cially true in the Northeast. In the words of] Rodenhiser, "I believe it's vital to see that air pol tion research in the field of agriculture moves ahc . . . now . . . before we get even further behin

ECONOMIC CONSIDERATIONS IN AIR POLLUTION CONTROL

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A discussion of the economics of air pollution control is hampered somewhat at the outset by an awareness of much that has previously been said on this subject, and duly set forth in the literature. If one reviews this rather extensive literature, a certain amount of repetition becomes evident, as might be expected, and in fact, it is quite difficult to discuss the subject without resorting to the use of what have very nearly become platitudes concerning the economic aspects of air pollution.

It is my desire not to review what has previously been said so well by others, but instead to offer several thoughts on some matters which seem timely, and which may be controversial. It is perhaps unnecessary to state my qualifications for this discussion, but inasmuch as they are not lengthy it may be of use to do so. Some months ago, it was my privilege to participate in a "Seminar on Air Quality Standards" held at the University of Michigan in Ann Arbor. Although I have in a sense been concerned with the economics of air pollution for many years, I had never previously spent several consecutive days engaged in discussion solely devoted to this topic. Inasmuch as the discussion group contained representatives from various industries, government, and educational institutions, a variety of views were expressed. Although the present discussion is not a report of the results of that Seminar, some of the ideas presented grew out of it.

For convenience in thinking, the total cost of air pollution to the community may be conveniently divided into two categories: (1) costs or losses suffered as a result of the pollution; and (2) costs of doing something about it, or costs of control. Traditionally a number of types of air pollution damage are recognized, and estimates have been made of the nature of the economic losses, as well as their magnitude. Similarly, the costs of control are divided into several well-known subgroups for discussion purposes. At this point it is necessary to clearly separate considerations of the effects themselves from considerations of the economic import of the effects. This may appear self-evident, but it is not always so, and a lot of confusion can result when technology and economics are not separated. For example, a discussion on vegetation damage by an air pollutant may be concerned solely with the nature of the damage, its causes, etc., and need never make reference to the value of the crop to the community. In arriving at economic judgments, however, the same subject must be treated in such manner as to enable intelligent appraisal of its economic impact on the community. Thus, no matter what biological or biochemical mechanisms are involved, nor how striking the damage appears in a color photograph, an estimate can, and usually must, be made of the magnitude of actual losses suffered in any particular situation. This distinction is not too difficult to make, and whenever the total cost of air pollution damage is to be reckoned, it must be made for each type of damage known to be involved.

The importance of this procedure rests on the fundamental tenet that decisions regarding air pollution controls must of necessity be based on economic considerations. Not everyone will agree with this statement, and it may be quickly added that such decisions are based only partly on economic

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considerations, partly on known or suspected health effects, and perhaps partly upon the extent of any nuisance involved. This seems to me to be a misconception which refuses to recognize that air pollution control measures are without exception the result of some kind of economic judgments. If this be true, then the criteria for establishing that further controls are needed must similarly be translated into economic terms. I believe that this concept should be well understood, and applied to every situation where a decision regarding control measures must be made. There have been many instances where the presence of an air pollutant, coupled with knowledge that it can cause or has caused a certain effect, is deemed sufficient reason to bring pressure to bear so that the pollutant is eliminated. Very often, of course, the action is well justified, but on other occasions the cost of control is so much greater than the losses being incurred that the community or its officials should act with caution. It is the community's privilege, of course, to reduce pollution levels as much as it wishes, no matter what the cost, and no matter for what reason, but there should be an awareness of the relative economics of any given situation, based on sound estimates made by responsible officials. In summarizing, then, the point has simply been made that judgments in air pollution control should be based on economic considerations, and that all other factors must be translated into economic terms.

The next point for discussion is actually no different from the one just made but, because human health is concerned, it is deserving of special comment. Most persons will concede that damage to materials, vegetation, or livestock is essentially an economic matter, but when human health is concerned, opinions differ sharply. Nearly all agree that the costs of human illness resulting from air pollution can be estimated, but opinions differ on the desirability of doing so. In other words, there is a common tendency to agree that damage to property is best expressed as a certain cost to the community, but human health must not be so treated. More correctly stated, perhaps, there seem to be objections to the concept that human health effects ought to be translated into economic terms before decisions on control procedures are made. This latter view, in my opinion, is unrealistic and may do more harm to the community than the more material approach. Let me amplify on this matter. Although it is exceedingly difficult to estimate the direct costs of human illness and loss of life, it is possible to make reasonable estimates of the costs of control measures which it is believed will in some way reduce air pollution levels to a point where these effects are no longer suffered. The argument is not academic, for although our knowledge of the health effects attributable to prolonged exposure to urban air pollution is incomplete, each year the wealth of information resulting from research studies must be interpreted, and along with information comes the necessity for responsible persons to take whatever action may be indicated. Whenever such actions are taken, an economic decision has been made, even though the basic grounds for the action were some new evidence concerning human health effects.

It should be self-evident that responsible public officials and others who help set policy must consider the complete spectrum of costs which are related to their decisions. Effort must constantly be made to estimate and add up all of the costs attributable to air pollution, and at the same time treat in similar fashion the costs of achieving any desired degree of control. It is in this regard, I feel, that a much better service could be rendered to the community than often is the case. The public is periodically warned in the popular press of the many consequences of uncontrolled air pollution. Sometimes it is told that the costs of air pollution in any particular community run as high as several millions of dollars, and on a national scale into billions of dollars. Too infrequently, however, adequate information concerning the probable costs of reducing air pollution to a point where many of the effects cited will no longer occur is not simultaneously presented. I have many times read newspaper or magazine articles telling how many tons of "filth" are in the air, but the same logic which integrates parts per million concentrations into tons per several cubic miles of air doesn't seem to apply when and if control costs are mentioned. In the case of vehicular exhaust, for example, the unit cost per vehicle is often cited, and not the total obtained by multiplying this cost by x million vehicles. The example is not meant to have any bearing on the auto exhaust controversy, but simply to demonstrate a principle. It could be stated that in order to reduce the air concentration of a substance from x parts per million to y parts per million, the community will be required to spend many millions of dollars. The bias would now be in the

There cannot be much doubt that the annual cost of air pollution damage in any community greatly exceeds the annual cost of all control measures currently being exercised by that community, and the same is true on a national basis. There is, therefore, more than ample justification for expansion of air pollution control activities at every governmental level and within industry. The tremendous cost of some air pollution control measures, however, makes it absolutely imperative that decisions be made with the greatest possible wisdom. The public is usually unaware that the sheds and collectors erected on many industrial buildings for the purpose of reducing the amount of some waste product emitted to the atmosphere can cost hundreds of thousands of dollars. More importantly, the public should be informed that in order to put up similar structures for future problems, or in order to reduce vehicular emissions to some predetermined level, or in order to rid a neighborhood of an undesirable odor, or simply to do away with the annual ritual of leaf-burning in our major cities, a very real economic judgment is necessitated. Using leaf-burning as an example, it has been estimated by officials of the city of Detroit that it would cost in the vicinity of one-half million dollars to have the leaves carried away instead of allowing them to be burned in the streets. The City Council of Detroit annually decides that it cannot afford to rid the city of the nuisance this year, and the leaves are burned again. Rarely, however, is the particular pollution so well-defined, or the cost so accurately estimated, and frequently great pressure is applied to achieve a certain degree of air pollution reduction, with little or no apparent regard for the economic impact of the action. It is perhaps trite to tell the public that eventually all costs are borne by the consumer, or taxpayer, depending on the nature of the argument, but I doubt that a truer statement can be made.

I should like to urge that in the coming years, as our knowledge inevitably increases, all professional persons in the field of air pollution study use the utmost care in applying this knowledge. Air pollution control measures should be recommended which do the greatest possible good for the community at minimum cost. Further, funds spent for air pollution control should be in balance with funds required to control other factors which affect man's health and well-being. In most States and vanishingly small in some cases. In other areas, however, it is possible that in the near future the optimal expenditure of community resources is being approached, and care should be taken that excessive pressure is not exerted to try to force the community to spend more on air pollution control measures than it rightfully should. I have no way of knowing where the optimal point is, but recommend strongly that our public health officials constantly integrate the large number of variables which go into the economic balancing of air pollution damage costs and air pollution control costs.

One final point arises from the previous considerations. At the present time, and doubtless for many years to come, expenditures for air pollution control should be made by individual communities with their own unique socioeconomic status in mind. A community lacking adequate sewage disposal facilities, and barely able to maintain minimum police and fire protection services from year to year, may not elect to buy the same quality of air that a more prosperous community feels that it can afford. This is not to say that the poor community neither wants nor is entitled to clean air—it simply isn't its major problem at this time. I am not here defining a community as a city, county, or State, for no matter what size political entity is considered, the necessarily "local" nature of air pollution control should be respected. It seems particularly important that decisions made by some of our larger cities, where the necessity to reduce air pollution levels is no longer seriously questioned, should not be made to apply to all communities, irrespective of their actual needs and, more importantly, their ability to foot the bill.

Everything that I have so far stated can be summarized as follows:

1. Decisions on air pollution control measures are essentially economic judgments which require that all known effects be considered in terms of their total cost to the community.

2. Effects on human health should similarly be expressed in economic terms for the sole purpose of giving them their correct relative economic weight.

3. Control of air pollution must still be considered the function of individual communities, acting to achieve the highest quality of air consistent with community economics.

These statements may well be as platitudinous as some I had in mind at the beginning of this discussion, but they seem to me to be somewhat less frequently uttered, and I hope they are sufficiently challenging to arouse some controversy. Almost immediately they can be criticized because they are so nearly impossible to carry out in day-to-day control work. It is easy to say that a dollar value should be placed on health, or a disagreeable odor, or the sense of well-being that is lost in a polluted environment, but how do you do it? If my health were in jeopardy, would I want a control official to tell me that the community had done a cost analysis and had concluded that my net worth was insufficient to warrant any action? Naturally, I can't answer these questions, and almost certainly I, as an individual, would behave quite like other citizens in similar circumstances. This has little relationship to the argument, though, for all public health measures, or for that matter virtually all community endeavors, are directed at serving the best interests of the maximum number of persons possible. In fairly coldblooded fashion, for example, a State highway department will not put up a traffic light at every intersection where there has been an accident, and even petitions for them by neighborhood groups are often ignored because budgets are finite, and other, more dangerous intersections have a higher priority. Such an attitude doesn't belittle or deny the hazard, it simply assigns an economic weighting to it in relationship to similar hazards. We in air pollution study must, and for the most part do, think in similar fashion, and urge the adoption of those measures which in our judgment give the community the greatest return for its investment.

In attempting to make educated estimates, we instinctively recognize the relative importance of the various types of air pollution damage, so that a lot of differences in opinion on the principles involved lose their vitality when real situations are considered. Sometimes, though, the differences seem unresolvable, as in those instances where someone proclaims that air purity must be maintained at such levels that no single member of the community will be adversely affected. Such an attitude can be demonstrated by analogy to be impractical, and one of the best examples of its contradiction is found in the record of industrial hygiene accomplishments during the past 25 years. The problems of industrial hygiene are similar to those of air pollution, and indeed they now overlap to such an extent that they are no longer clearly separable. Industrial hygiene has long been engaged in providing air of ever-improving quality in our work places, but its standards never have been, and possibly never will be, set so that the most sensitive members of the worker population will experience no adverse effects. Of course, there are some pertinent differences between a population of workers and the population at large, and a 40-hour week vs. a 168-hour week, but the guiding principles of industrial hygiene and air pollution study should not be fundamentally different. I think that, beyond any doubt, the industrial hygiene approach has been shown conclusively to have resulted in tremendous gains in the quality of in-plant air, with resultant reductions in occupational disease which are matters of record.

It is very easy to frighten the public on matters relating to air pollution. For some reason, speculative statements that some poison or other in the air is harmful are readily believed, but the same populace cannot be dissuaded from smoking, refuses to buy seatbelts, and is relatively unconcerned about many other health and safety hazards. It is the responsibility of all concerned with air pollution control to demonstrate a maturity of judgment which recognizes the rightful importance of this problem in relation to man's continuing efforts to improve his environment.

Prepared Discussion: ECONOMIC CONSIDERATIONS IN AIR POLLUTION CONTROL

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Dr. Smith has presented an approach to the problem of economics which leaves very little room for argument. In essence, he has told us that all aspects of the air pollution problem can and must be reduced to economic values before an intelligent and informed decision can be reached. This is certainly true and this principle can be applied to any problem ranging from the family budget to foreign aid. Unfortunately, we do not always follow this rule; I speak authoritatively with regard to the family budget and I have some suspicions about foreign aid.

Dr. Smith's elaboration of the theme is quite interesting because it is the best summarization of the position of business and industry that I have had the opportunity to read. It is doubly interesting because it is the position which has gained for business and industry the reputation of being uncooperative in matters of air pollution control. The general public, as well as many public agencies, tends to overlook the fact that economic principles govern the business world. This is not to say that industry has no interest in its employees or in the community. On the contrary, industry recognizes the rights of these people more often than they recognize the rights of industry.

In this day and age, no responsible group of businessmen would knowingly submit employees or neighbors to conditions which would inevitably lead to death or disability. Similarly, industry continuously strives to avoid subjecting its neighbors to property damage or nuisance. It is a seldom realized fact that most of the air pollution problems existing today are a result of people locating their homes near long-established industry, or in established industrial centers. In recognition of eventual encroachment, most modern industrial plants are equipped with air control devices and are surrounded by acres of company-owned land.

The gradual encroachment of residential development upon industrial centers poses some very interesting economic problems in air pollution control. Picture, if you will, a large steel manufacturing center which was originally "out in the country" and which possessed quite adequate controls for those conditions. A large city develops and eventually homes are built up to the fences of the various industrial activities. A community demand develops for better air pollution control and laws requiring installation of equipment are passed. Who decides what reasonable length of time shall be allowed for the installation to be completed? In terms of economics, many millions of dollars will have to be spent by industry to comply with the new laws, millions which will have to be diverted from production improvements and from dividends to investors. It may be impossible to comply with the new laws immediately without wrecking the economic stability of the industry and of the community. It is therefore imperative, as indicated by Dr. Smith, that the local community take action with full cognizance of its economic capacity.

With regard to balancing the economic losses due to air pollution against the cost of control to industry and to government, there is, as Dr. Smith has indicated, a tendency to overemphasize the dramatic aspects without regard for their real economic values. Unreliable estimates of national

losses or accurate estimates for any one city have little or no bearing on the situation in another city. The fact that a given city has more suspended particulates that another does not mean that significant economic losses are occurring in either location. Articles in the popular press which report that certain diseases are statistically associated with air pollution only cloud the issue and introduce emotional problems which make it difficult to arrive at a rational evaluation of the problem. I do not deny that damages occur from air pollution, or that there are statistical relationships between certain diseases and air pollution; the point is that this sort of material implies that these things happen wherever air pollution occurs without regard for the composition or source of pollution or for the ability of the community air to accept domestic and industrial wastes. Action should be based on accurate local evaluations of hazards to life and property and balanced against the economic needs of the community.

The potential economic impact on industry and on the community can easily be underestimated. It is frequently said that air control devices pay for themselves in recovered raw materials or by increased efficiency of operation. Although true in a few cases, this is not the case as often as suggested. For the most part, air control devices represent added costs to business. Not only does the capital cost of purchase and installation divert huge sums of money, but also, the cost of operation adds to continuing overhead expenses in production. Higher costs mean less profit; lower profit means reduced tax income to government, increased cost of consumer items, and decreased return on investments. Lower profit also influences the competitive position of industry. Management is not inclined to devote the capital funds for improvements or expansion to plants which are in a poor competitive position; the growth of the plant is slowed or stopped and the opportunities for growth of the community are similarly affected.

The economic significance of air pollution control to the individual citizen is becoming more and more evident. The smog problem in California has made greater demands on individuals than in any other area. In addition to the indirect influence of air control in industry and the direct taxation for governmental services allied to air pollution control, Californians soon will be required to equip their personal autos with air control devices. From recent reports, it would appear that similar requirements will be made on residents of other States in the not too distant future. An interesting potential for private citizens exists in Spokane, Wash. A recent report of a survey of that city indicates that the most significant portion of community air pollution arises from space heating in the winter months. The possible requirements for a changeover to efficient furnaces or installation of control devices on existing heating plants would undoubtedly make many a private citizen unhappy.

The scientific aspects of air pollution control should not be overlooked as an economic item. Although these activities are not direct costs of control, they are associated with the problem. Research aimed at defining the problems of specific communities or establishing the effects of a given pollutant on vegetation, animals, and humans is not accomplished without cost. Both industry and government are spending sizable sums on such research at both private and public institutions. It is absolutely necessary to finance these activities so that the community and the industry can be sure that they are spending money wisely. To adopt standards without research, whether the standards apply to allowable emissions or to ambient air quality, is to put the cart before the horse. If the standards are more severe than needed locally, industry must spend more than enough to control pollution; if the standards are not sufficiently strong, money will eventually have to be spent to replace inadequate equipment at a greater cost than the correct installation made initially.

In addition to the research aspects, there are other significant scientific costs to air pollution control, especially in the newest concept of community control, ambient air quality. It is indeed a noble and ambitious undertaking to define the acceptable levels of all the pollutants in community air, but it is necessary to consider how these standards will be enforced. The cost of ambient air quality promises to be high if it is to be realistically enforced. The air will have to be monitored for each of the pollutants either continuously or at regular intervals. Such monitoring requires collection and analysis of samples, either by instrumentation or by crews of technicians. In either case, well-trained and adequately paid personnel will be needed to conduct these activities, administer the program, and interpret the results. These costs, when added to enforcement costs, will cer-

increased or other services reduced.

These comments can be summarized to be in basic agreement with Dr. Smith in his conclusion

tain his environment as a healthful one, but it must be done with proper regard for all the factors which determine his survival.

EFFECTS OF AIR POLLUTION ON URB/ PLANNING AND DEVELOPME]

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INTRODUCTION

The problem of maintaining clear air for breathing and all its other uses is coming to vie in difficulty with that of maintaining ample clear water for drinking and all its other uses.

More and more often, more and more people wake up in the morning to yesterday's stale air, heavy with its load of acquired contaminants; and even our most lovely cities, threaded with green parkways and conforming gracefully to their land contours, have little appeal when shrouded in sluggish veils of eyestinging smog.

The congestion and wastes of urban life, willy-nilly, have made study of windspeeds, wind directions, inversion heights, and local air eddies as important to planning as study of topography, soil types, and population trends.

Regional planning on the basis of airsheds, as on that of watersheds, is long overdue.

That the matter is not peculiar to a few unfortunate locations is illuminated by some recently published figures (Schueneman). According to these estimates, all urban places of 50,000 and over in the United States have some kind of air pollution problem. Eighty-eight percent of our urban population and well over half of the total population live in these polluted areas. On the basis of 1950 census figures, this indicates that about 84 million are exposed to air pollution—37 million to major problems, 22 million to moderate ones.

And air pollution is no respecter of political boundaries. Statewide surveys show that one city out of every six studied has some sort of problem due to pollutants arising outside its jurisdiction. In about 25 States there is need for multicoun pollution control, and if multicounty agencies called for wherever afflicted counties do not large enough populations to support their programs, there would be need for such ag in nearly all the States.

Twelve States now have authority to enfor pollution regulations on a statewide basis, an have programs implementing that authority.

Only about half of the people exposed pollution live in communities served by loca trol agencies. Many of these agencies, mor have inadequate staff and resources to cop their problems.

In view of the extent of exposure to sev moderate air pollution, it appears that th need for great expansion of control program

Questions are likely to arise, therefore, much on the basis of need for air resource m ment, as on our ability to predict and cont quality, on the type of agency best fitted to job, and on the administrative tools availa inventable.

What meteorological and topographica are needed by the up-to-date urban planner such data readily available?

How much should the planner know abc sources of air pollution, in order to plan land use and physical development of an ar

What geographical area should be consid planning to prevent or to solve air pc problems?

What are the tools of control? Are the the planner's kitbag, or should there be tea with other agencies?

How large (or small) are the areas of conflict between air pollution control and other legitimate goals and needs of the modern community?

NATURAL DILUTION CAPACITY OF AIR

Air pollution in a region is a function of areal activities and weather conditions. Knowledge of such factors as wind directions and speeds (both to some extent a function of time), windflow patterns as affected by large land features, amount and times of precipitation, and daily and seasonal amounts of sunshine, permit the tracing of airsheds or meteorological-topographical districts on maps already recording land use, population densities, traffic flows, and other demographic data. For each such district the overall natural dilution capacity of air may be estimated, and studied in relation to indications of the amount and kind of contaminants likely to be produced there or received from external sources.

Local variations within the airshed are also significant. These will depend on the location of pollutant sources, surface roughness retarding air movement by friction, and such temperature and topographical differentials as create local flow patterns which vary considerably from prevailing wind directions. (Sea-land breezes and mountain-valley winds are examples of such local winds.) But unfavorable topography is not a necessary factor in pollution buildup. Extreme pollution concentration may develop in a city on a plain, provided source strength is great enough compared with diffusion rate. There is enough surface roughness in a city situated on a flat open area to make it a better sink than the surrounding countryside for stagnant pools of air.

The natural dilution capacity of an area is relatively fixed by meteorological and topographical factors, whereas populations and sources of air pollution may be assumed to be constantly growing over a period of time. Consequently, most settled areas will in time come to require regulation of the emissions of air contaminants which, in concentration, can produce chronic nuisance, health hazards, and extensive damage to vegetation, animals, and property.

The usefulness of the airshed concept for planning to prevent and control air pollution will hinge on ability to determine dilution capacities and air pollution levels with objectivity. What is the present state of knowledge of these phenomena?

DETERMINING DILUTION CAPACITIES

Through continuously operating systems of surface wind-observing stations, utilizing those of air pollution control districts, industries, Armed Forces, and the U.S. Weather Bureau, it is now possible to draw reasonable inferences as to the frequency of weather conditions within an airshed which would be conducive to high air pollution levels (Wexler). With the addition of knowledge of local flows and their variations in time, it is possible to develop hourly maps which show existing airflow patterns over specific areas.

Such airflow maps have permitted the Los Angeles Air Pollution Control District (which has used fluorescent tracers to verify its findings) to follow the course of an air pollution parcel with some accuracy (Holland et al.). Knowledge of such trajectories has proved of practical value. It has enabled the District to show that trajectories of polluted air did not travel over refining sections, but over high-density traffic areas, indicating that automotive vehicles rather than refineries are chiefly responsible for air pollution over central Los Angeles. The District's area has been divided into a grid system on which all locations may be identified by *x*- and *y*-coordinates. Public complaints are entered on land use maps, and trajectories plotted backward in time. By noting crossing of trajectories from two different groups of complainants living in different parts of the city, it has been possible to pinpoint local sources of accidental releases of pollutants. Using electronic data processing and IBM programming, the District finds it possible to shorten the time it would otherwise take to locate the source of significant emissions of some objectionable air pollutant.

Data on the amounts of sunshine received diurnally and seasonally by an area are obtainable from long-term climatic records at weather stations; and the relation of air movement to land features like mountains, valleys, large bodies of water, and so on, may be discovered without great difficulty.

Rain and drizzle, sun and water vapor, are effective air cleaners, and large bodies of water dissolve air pollutants at their surface. Data on precipitation and water surface are easily obtained.

The interplay of three factors—patterns of wind flow and velocity, local topography, and hours of sunshine per day or month—largely accounts for the presence or absence of temperature inversions over an area; and inversions are most important

concentrators of air pollutants. The term "inversion" is used to describe a condition which is the reverse of the usual drop in temperature with elevation (calculated to be about 5.5° F. for every 1,000 feet of elevation)—namely, a rise in temperature with height until the "ceiling" of the inversion is reached, i.e., the point where temperature begins again to drop with height.

There is minimal vertical mixture under inversion conditions, so that an air parcel carrying a load of contaminants, temporarily displaced by some local force, will tend to return to its former position when the force is spent. As a result, air pollutants become concentrated, visibility decreases, and (with persistent sunshine) photochemical reactions create new and often highly irritating substances in the air.

Foreknowledge of persistent inversion conditions is of great importance. A stagnation forecast service is in use in air pollution control in eastern Tennessee, and a similar service operates for the whole eastern United States (Wanta).

Holland and his associates state that climate like that of Los Angeles and vicinity, in which deep temperature inversions occur for long periods of time, characterizes at least four other regions of the world—the northwest coast of Africa, the west coast of South Africa, the southwest coast of South America, and the east coast of Australia. They suggest that industrialization should be discouraged in these areas so long as alternative localities are available (Holland et al.).

Greenburg and Field believe that weather conditions favoring unusual incidents of air pollution in which inversion has played an important role sometimes extend over thousands of square miles. Analysis of a 1953 incident in New York City, at first thought to be local in character, was shown to be part of a persistent meteorological pattern bringing inversion conditions to most of the eastern third of the United States. They urge that, in studying air pollution, consideration be given to the entire area involved. They believe the total effects of air pollution on health, because of these widespread conditions, may be far greater than previously suspected from epidemiological studies (Greenburg and Field).

In the past decade great advances have been made in climatological studies motivated by the need to be able to forecast with some accuracy how fission products would diffuse in the event of a nuclear reactor disaster. Meteorologists working out of Brookhaven, Hanford, and Oak Ridge have been able to forecast accurately the concentration of fission products that would be found downwind from an emission of known characteristics (Eisenbud).

We may conclude that enough can probably be known, both about overall and localized meteorological characteristics of a region, to make the calculation of regional air dilution capacities feasible and the use of the airshed concept in land use planning practicable.

CHIEF SOURCES OF AIR POLLUTION

A brief review of the major types of air contaminants will remind us that the chief point sources are industries, home heating and backyard burning, and burning dumps. Agricultural practices like smudge burning in orchards and airplane spraying of insecticides may also be sources of air pollution to nearby cities. Vehicles of transportation, and above all the automobile, are the chief mobile—and in many communities the major—remaining sources.

In addition to emissions which might be located on a grid map, there are those which are areawide—a stew of the residual contaminants from all controlled and uncontrolled sources, mingling and interacting in the atmosphere.

A special case is that of two adjacent point sources whose effluents produce a pollutant which neither would create by itself. For example, a synthetic rubber plant which uses butadiene and styrene, located near a chlorine or hydrochloric acid plant, in a predominantly sunny climate, may produce lachrymators which are annoying in extremely low concentrations. Baton Rouge, La., the Sarnia-Port Huron area on the Great Lakes, and strips along the Houston Ship Channel, have learned this to their sorrow (Katz).

Deferring for the time discussion of areawide sources of pollution, we might think in a schematic way of four stages of the process by which air pollution of any type becomes a significant feature of urban life.

Air contaminants must first be produced; then released to the air; then carried about by air currents (possibly mixed with other pollutants from adjacent areas, and with sufficient exposure to sunlight, chemically altered); and then received by plants, animals, people, or nonliving surfaces. (Lessened visibility may be one effect "received" by people deprived of distant views.)

instead of releasing it to the atmosphere. (3) We may require sources to locate only where meteorological conditions favor rapid atmospheric dilution and dispersal—and at the same time prohibit such a dense grouping of sources as to make this impossible. (4) We may safeguard potential receptors by keeping a safe distance between them and the sources of harmful pollutants—a distance, in some cases, sufficient to guarantee good visibility.

There are obvious physical and economic limits to each of these.

CONTROL OF POINT SOURCES

Industries

1. Where economics will permit, the simplest control is by prevention, by ceasing to produce the contaminant. This counsel of perfection is not easily followed by plants already built and in operation. But zoning to prohibit the building in critical receptor areas of new plants using certain types of raw materials, fuels, or processes is sometimes practiced by planning commissions. And where methods are known for accomplishing the same industrial task with harmless end products, an air pollution control district may hold hearings to learn whether or not, if areawide regulation should require all plants to shift to the harmless process, undue economic hardship would result.

2. In some cases pollutants may be contained on the premises. Smelters, metal and aluminum plants, and other large operations producing particulate contaminants, may be required to own a sufficiently large land area to make likely that most airborne wastes will be deposited on company premises. Well known are various collection devices which prevent the release of contaminants to the atmosphere. It is not unusual for plant owners, having been required to install such devices, to discover unexpected savings from salvage of previously wasted end products.

For these two types of control (by prevention or containment), a classification of the major industries of the area is a useful planning tool. The standard industrial classification used by the U.S. Census Bureau permits estimating the comparative total contaminant loads of different types of industries—e.g., petroleum refining, rock crushing, as-able, is classification of industries on the basis of the nature and extent of emissions of specific air pollutants which an air pollution control district will permit—i.e., performance standards based on community air standards.[1] This creates an incentive to industries to improve control in designing new plant. However, performance standards may not be feasible when there is not a well-staffed air pollution control district to provide the trained enforcement personnel. Also, the development of such standards usually requires many months in which to obtain data and testimony for fair "rollback" ordinances for plants already built. Unless the standards issued have been approved by experts familiar with industries' problems, voluntary compliance will be unlikely and the enforcement staff will face impossible loads.

3. When dispersion to air is allowed, the techniques of dilution and dispersal must be studied, just as in water pollution—with turbulence, flow speeds, and mass emission loads all relevant. Industrial sources of pollution may be located in zones where these conditions are favorable, or prohibited by zoning from selecting sites in narrow valleys whose walls shield the area and lower windspeeds. With a view to thinning down mass emission loads, decentralization of industrial plant location may be advisable, or where meteorological factors and the location of urban communities indicate, concentration of industrial plants to the leeward of all inhabited spots may be a solution.

4. Sensitive receptors like residences and greenhouses may be zoned out of areas subject to heavy doses of harmful pollutants from already established industrial plants which cannot be moved.

Dump Burning

Open burning of the accumulated waste and refuse of our cities is usually the first to be prohibited in any program of air pollution control. This may be partly due to the fact that the pollution from this source is visible to all, and that the owners of dumps

[1] Community air standards, preferably developed by the Public Health Service, are usually expressed as maximum allowable atmospheric concentrations of specific pollutants, for given intervals of time, given in lbs./cu. ft. or tons/cu. mi.

receive less sympathy than some other segments of the community, as well as because alternative methods of disposal are usually possible without undue economic hardship. Planners may make burial of comminuted material with alternate compressed layers of earth the occasion for planning new open spaces suitable for recreation or light building. Where a regional refuse disposal plan can be instituted, zoning for conformity to the plan is ideal, and the foresight involved in planning often enables the reservation of suitable land areas in advance of rising prices. Also to be encouraged is joint financing among communities of a plant to convert organic materials from waste into usable forms, or joint financing of an efficient incinerator for combustibles.

Home Heating and Backyard Burning

Air pollutants from home furnaces may remain an irreducible minimum in any area, but in England the burning of soft coal has been prohibited in certain cases, and where it is possible to use hydroelectric power or solar power for home heating, this problem perhaps could be eventually solved. Meantime, in Los Angeles County in 1959, it was found that residential land uses contributed less than one percent of the total contaminant emissions, after prohibition of backyard burning (Brievogel et al.); so that even with increased population density, this source may be minor as compared with other uncontrolled sources.

CONTROL OF MOBILE SOURCES

Other panels of this Conference are discussing the relation of emission from automobiles, trucks, and busses—the chief mobile sources of air pollution. Engineering to control unburned hydrocarbons from auto exhausts and evaporation from crankcases is no longer a luxury. It is now mandatory over timed stages in California, and will no doubt produce a revolution in automobile manufacturing. However, any device is only as good as its maintenance, and no device will be 100 percent effective, so that other control measures will be essential. We shall discuss this under the topic of planning to prevent areawide air pollution.

It is sometimes maintained that regional rapid transit can solve the motor exhaust problem by replacing millions of private automobiles with either electric trains or with far fewer busses maintained in good condition. Such a hope is foredoomed. Important as rapid transit is, the resulting air pollution rollback will soon be wiped out by increasing population if present urban settlement patterns continue. Significant reduction of air pollution will take the leverage of all the factors we can think of, but above all, it will take fundamental redesigning of home-job and home-recreation relationships. It is not possible to solve air pollution as a separate factor. It is part of the whole pattern of urban development, both at the fringe areas and in the centers of cities.

GEOGRAPHICAL AREA APPROPRIATE FOR AIR POLLUTION CONTROL

Although this paper's title refers to "urban planning and development," it may well be argued that the city is not an appropriate entity for control of air pollution. As administrators soon discover, the most thoroughgoing local efforts will be unavailing if contaminants from unregulated areas, outside the police jurisdiction of the community, blow into the controlled territory.

It is well known that even counties may not be large enough for effective air pollution control—in fact, that air pollutants move about without regard for political boundaries. Successful attack on air pollution has sometimes required multicounty, interstate, and even international agreements or jurisdictions.

A number of States have set up statewide air pollution control programs (Rogers and Edelman) either as independent authorities or as part of the department of health. But the State is not necessarily the ideal basis for such programs, both because conditions typically vary widely over the State and because local sentiment and experience need to be consulted and given voice from the outset if compliance is to be satisfactory.

A State may legislate directly to control air pollution which threatens to damage public health and welfare, or it may delegate this power to a municipality or other public agency. In such case, the legislation must establish adequate standards to guide the enforcing agency, and its requirements must not be arbitrary.

The suggestion developing from the fact that knowledge of climatological, demographic, and other data is available is that air pollution control districts be cut to fit the cloth of the natural boundaries containing this truly regional problem.

air pollution control research and provide technical assistance to local government and agencies. Area surveys might then be conducted on a statewide basis, including population and population trends, industrial activity, fuel consumption for space heating and power, automotive usage, waste disposal practices, agricultural activity, and local and regional topography and climate.[2]

On the basis of such a survey, several regions might be roughly delineated within the State, adjusting boundaries so as to not to divide included cities or counties.

The State might then pass a general enabling law authorizing the creation of regional districts with power to adopt comprehensive regulations establishing the limits of specific contaminants from sources within their jurisdictions.

The governing boards of such authorities might well be drawn from officials elected to other local office; i.e., county supervisors and mayors or councilmen of the included jurisdictions.

The costs of the regional program would be met through taxes which the authority was empowered to levy (under State-set limits) upon included jurisdictions.

If research by the State agency showed need for air pollution control in a region, as judged by some predetermined level of pollution in ambient air, and the local governments involved failed to establish an air pollution control authority, there might be a "march in" clause empowering the State agency to assume jurisdiction, after a reasonable and specified length of time, the costs to be borne by the locality in question.

Because air pollution is a problem occurring primarily in urbanized areas, the establishing of districts to control air pollution should be considered in connection with the whole family of problems crying out for regional treatment. Thus, while air pollution control districts might be set up without waiting for the creation of a regional limited-function government to consider all areawide problems of physical development—e.g., water pollution, regional rapid transit, regional parks and open space, bridges and freeways, and regional planning for all these—the enabling legislation should be so

[2] Rossano estimates that a statewide survey of this character should require about 9 man-months of fieldwork and an equal time for analysis.

This is not the place to discuss at length alternative forms of metropolitan government which might supplement and strengthen city and county government, without depriving local citizens of the opportunity to make decisions on the wide variety of truly local programs. But any discussion of the problem of air pollution control will fall short if it does not rapidly recognize air pollution as one of a whole syndrome of physical development problems which call for a regional plan and some limited type of metropolitan government.

THE TOOLS OF AIR POLLUTION CONTROL

The planning agency is not usually, and probably should not be, the agency enforcing air pollution control ordinances. The planner's problem is one of locating residences, industries, and agriculture, parks, recreation areas, and freeways so as to minimize conflicts of interest while permitting normal areal growth. The plant owner, the other citizens of the community (present and future), and nonresidents downwind from the area, may all have interests affected by air pollution. A carefully drawn regional plan is a minimal necessity for consideration of all the interests involved. Such a comprehensive plan, developed after adequate community hearings, and including as basic data the meteorological conditions of the region, will have the best chance of demonstrating that any particular zoning proposal is reasonable.

Zoning is the planner's chief tool of control, and his ordinances must show in every case, of course, a reasonable relationship to the health, safety, or welfare of the community in order to justify use of the police power. Zoning may be for site location of an industry or of an industrial park, in which case the planner should have due regard to local and regional weather phenomena, topography, real estate values, future growth trends, existing sources, receptors, and concentrations of air pollution, including that which comes into the area from outside. Zoning may regulate lot size, the placing of the building on the property, proximity of receptors to sources of emissions, or industrial processes per-

[3] This is consistent, I believe, with one of the major recommendations of the California Governor's Commission on Metropolitan Area Problems. See app. A.

mitted within the area; but when it comes to performance standards to regulate areawide air quality, there is need for an air pollution control district.

Ideally, a well-staffed air pollution control district and a planning agency, covering the same geographical area (preferably an airshed) establish routine relationships by which each assists the other. The district may furnish the planner meteorological and topographical data to help him guide physical growth pattern by land-use restrictions. Such guidance will tend to prevent point-source air pollution problems from arising, thus saving costly mistakes and litigation. The district also can assist by adopting performance standards for industries and by furnishing specific information on processes used by industries requesting changes of zone or use permits.

Districts sometime compile lists of industrial uses or operations which serve as the basis for automatic referral by the planning commission to the district. Review is called for in respect to both local and areawide effects of emissions to be expected from industries applying for rezoning or for the issuance of variations and exceptions. As a layman, the planner can be aware of visible fumes and dust fallout, but only the expert can know the invisible gases involved, capable of producing human discomfort, vegetation damage, and property devaluation—some of which might be avoided through proper industrial location. Objective advice from the air pollution control district increases the information available to the planner and encourages more balanced judgment of competing claims in a community.

But comprehensive planning for the physical development of an area has a far more intimate and pervasive relation to air pollution control.

This relationship stems from the fact that automobiles contribute the overwhelming proportion of pollutants in communities in which air pollution control is well advanced, and through sheer growth in numbers of car owners will be likely to continue to do so even after rather effective control devices become the rule. It is not likely to be possible or desirable to try to limit car ownership or use. The remaining course would seem to be to reduce, by urban planning, the miles of commuting which are now typically necessary in sprawling metropolitan areas, between homes and places of employment, between homes and recreation. This can be done by guiding new community growth.

If other considerations did not lead to identical advice, only a weak case might be made for such a recommendation. But in point of fact, the advantages of reducing commuting miles and weekend travel in search of playspace, are legion.

Dispersal of employment opportunities into clearly defined subregional cities with suitable homes and other facilities available close by would not only dispense with much unnecessary commuting—it would also improve the visual environment, bringing city and country into closer harmony and replacing endless formless strip cities with cities of character and shape. It would reduce costs of roads, schools, sewerage, and fire and police and other municipal services, by introducing compact relationships in place of metropolitan sprawl. At the same time it would tend to rationalize the distribution of taxes, which at present are often paid by permanent residents of the older cities although they go to underwrite services given to hordes of freebooting commuters.

Decentralization of industry, with varied choice in types of housing within easy distance of the workplace, could give rise to subcities of substantial size—250,000 to 1 million perhaps—which could still be psychological and corporate entities. A city of this size could support its own junior college, commercial and professional services, and cultural and social activities. At the same time it could be surrounded and invaded by woods and ranchlands reserved as permanent open space, by vineyards, orchards, farms, and truck gardens. Mountainous country, coast and bayshore lands, lakes, streamsides, major creeks, and other unique landscape features could be conserved for recreational activities. A regionwide transportation system could coordinate all types of transportation, reserving costly rapid transit for those few areas where local conditions present great difficulty to private transportation.

There would still be a certain amount of commuting, consistent with our prized freedom to choose where we will work, live, study, or play, and with our high degree of professional specialization. But the massive crisscross commuting—the long tedious rides to work and back, to recreation and back, would be cut and the chief source of air pollution reduced.

These suggestions are far from revolutionary. Urban development is contained within predetermined limits in Britain's New Towns, in Amsterdam, Rotterdam, Copenhagen, and Stockholm.

Stalingrad, for example, was laid out in two sections perpendicularly alined to the prevailing wind directions, resulting in a more favorable windward and a less favorable leeward side to the town. These two sections were further divided into multiple bands or zones, with the favorable section containing bands of parks, recreation areas, and residences, and the leeward section containing industrial plants, railroads, and a greenbelted freeway area—the latter separating the industrial from the residential areas, and concealing them from one another. The wind typically passes first over recreational and park areas, then over residences, then over the greenbelted highway area, then over the industrial and railway area. This design also permits homes to be located only a few miles from the major pollution sources—which are also the work places for many of the townspeople (Leavitt).

Such direct land-use control may not be desirable, and in any case, is seldom the American planner's prerogative. But wherever an urban region is spreading into agricultural or open areas, it is worthwhile to consider new concepts which might influence basic metropolitan planning at the fringe.

And great possibilities for improving urban design exist in our renewal programs. Obsolescence leads us to destroy so much of our cities that it has been said that a city largely rebuilds itself in two or three generations. Concepts like that of Hilberseimer's are worth considering in locating housing, industries, and for office buildings, theaters, and other centers of culture in neighborhoods. Schools could be so relocated in relation to heavy traffic thoroughfares that children would not have to cross traffic arteries between home and school or home and park.

Since every city and every region is in some important respects unique, the last thing desired is to suggest a design of regional or urban pattern wholly guided by considerations of air pollution control. But if the landscape, the climate, the topography, cultural traditions, and economic and political values, are all considered by the planner, city renewal projects are almost certain to reduce, incidentally as it were, the problems of air pollution.

Not only is there need for a regional or airshed approach to city planning, there is also great need for mediation between the Federal Government and local or regional communities in the development of effective policies for urban expansion. At present, under piecemeal planning by many Federal and State agencies, decisions on highways, public works, housing, and land use are often operating at cross purposes, defeating good local planning. The State is perhaps the natural mediator here.

Air pollution control is just one more problem pointing up the need for good Federal, State, regional, and local planning, coordinated at the State level.

Appendix

(Excerpts from *Meeting Metropolitan Problems,* Report of the Governor's Commission on Metropolitan Area Problems. Sacramento, December 1960, pp. 16–20)

PROPOSED FOR IMMEDIATE ACTION

Metropolitan growth must be directed to the conservation and economic utilization and enhancement of the State's resources and to the provision of a suitable environment for the people of California. At the same time, proposals for solution of California's metropolitan problems should be designed to maintain as much of the political decisionmaking as possible in the local community. Local citizens must continue to be provided with the opportunity to make choices about the structure and programs of their local government. The recommendations which follow call for the support and strengthening of local government in California so that it may solve successfully the emerging and changing problems of population growth now facing its citizens. To do this we recommend that the Governor take appropriate action to achieve the following:

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2. Permit the establishment by metropolitan areas of an areawide governmental framework through which truly areawide matters can be presented, discussed, decided, and acted upon on an areawide basis, as follows:

a. Enact enabling legislation permitting the establishment of a metropolitan area multipurpose district by a majority vote of the voting electorate within a defined metropolitan area, said district to be governed by a metropolitan council to be selected by, and from the membership of, the governing bodies of the cities and counties within the proposed metropolitan area multipurpose district. The enabling legislation should grant these districts taxing and bonding powers.

b. The enabling legislation recommended above should further provide that those functions permitted to be performed by any metropolitan area multipurpose district on

an areawide basis must include comprehensive metropolitan planning and one or more metropolitan functions such as:

(1) Air pollution control.

(2) Metropolitan water supply.

(3) Metropolitan sewage disposal and drainage.

(4) Metropolitan transportation, terminals and related facilities.

(5) Metropolitan parks and parkways.

(6) Metropolitan law enforcement.

(7) Metropolitan fire protection.

(8) Urban renewal.

(9) Civil defense.

(10) Any other metropolitan areawide functions which may be requested by the respective metropolitan areas.

The number and nature of the metropolitan functions originally included in the formation of a metropolitan area multipurpose district will differ in each area.

c. At any time subsequent to the establishment of such a metropolitan district, additional functions may, by a majority vote of its electorate, be added to its powers and no new and separate districts to perform government functions for substantially all of such metropolitan area shall be formed.

d. The enabling legislation should also include the provision that each metropolitan area in the State should submit to its electorate a proposal for a metropolitan governmental structure as soon as possible, and must submit such a proposal by January 1, 1964.

e. The Commission recognizes that as a metropolitan area multipurpose district is given an increasing number of functions it may be desirable to have some or all of the members of the metropolitan council chosen directly by the electorate in order to broaden representation by a cross section of groups in the metropolitan area: therefore, the enabling legislation should provide that the question of direct election shall be submitted to the electorate each 5 years after such a district is established.

3. Establish by statute a State Metropolitan Areas Commission to be appointed by the Governor and charged with the following duties.

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c. To inform, advise, and assist the Governor concerning the present and changing problems and needs of metropolitan areas in the State and the general problems of metropolitan government; recommend policies and action for the treatment of these problems;

d. To identify and delineate for the purpose of metropolitan area multipurpose districts metropolitan areas in the State on the basis of specified criteria;

* * * * *

f. To assist and encourage metropolitan areas in the initiation and undertaking of studies directed toward the development of a metropolitan government for their specific metropolitan area, if by January 1, 1963, these areas have not already done so;

g. Prepare for a vote of the electorate a proposal for a federated form of metropolitan government for those specific metropolitan areas which by January 1, 1964, have not produced such a plan and submitted it to their voters, and, in the event such a proposal is voted down, to require that a proposal for a federated form of metropolitan government be submitted not later than 5 years after each such unfavorable vote.

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DISCUSSION

E. Clinton Stokes. In recent hearings by Congress, there was mention of a report from a study conducted extensively on research projects and needs, both present and projected, for the Department of Agriculture and it covered about 279 different areas. Was air pollution research included as a part of this report and has any subsequent action been taken? Has the Department, particularly the Agricultural Research Service, requested research funds for this purpose? And what action has been taken?

Middleton. Dr. Rodenhiser, I'm sure that you as deputy administrator are in a proper spot to respond.

Rodenhiser. The answer to your first question is yes, for the construction of a laboratory to do basic research in this general field and also to staff this facility and provide funds for operating in this facility. As to your second question, on whether or not there is a request in for funds in fiscal year 1964, unfortunately I'm not at liberty to state what is in our request for this year until the budget has appeared in the President's message to the Congress.

George H. Hepting. I am associated with the U.S. Forest Service group doing the work on white pine damage from stack gas and ozone referred to by Dr. Rodenhiser. Since the stack gas research results are in press and not yet available, I would like to amplify his remarks concerning forest values and air pollution.

Eastern white pine is one of our most important conifer species from Canada to Georgia. Our investigations have demonstrated major injury to this species from industrial stack emissions. Trees are killed or reduced in growth up to 20 miles from several sources studied. While some acute sulfur dioxide injury has occurred locally around some sources, the nature of the pollutant or pollutant mixture that causes damage at greater distances is not known. Soft coal consumption seems the most likely source of such damage in some cases.

A second type of damage to white pine, under study since about 1900 and prevalent from Canada to Georgia, has been demonstrated by our group to be due to an oxidant, probably ozone (G. H. Hepting and C. R. Berry, 1961, Internatl. Jour. Air and Water Pollut. 4(½): 101–105). This is the pine equivalent of weather fleck on tobacco and results from ozone concentrations in the same range that cause weather fleck. We are not sure of the source of this ozone. Damage in remote forest areas, particularly in the North, appears unrelated to man's activities. It definitely seems related to certain weather patterns. In other areas this ozone damage could possibly result from air pollution oxidants.

In the case of both the stack gas injury that we call postemergence tipburn (PET) and the ozone injury that we call emergence tipburn (ET), there is great tree-to-tree variation in susceptibility. This variability has given us two valuable tools for our current and future research. One is the availability of a dependable, uniform bioassay for either PET or ET conditions through the simple multiplication of trees by grafting from susceptible lines. These are more sensitive and more useful to us than most chemical monitoring devices. The second tool is the resistant clone also readily multiplied by grafting. Such genetically uniform material from resistant trees has already been planted into what we call a "seed orchard." If the heritability of the factor for resistance to either stack gas or ozone is high, we can produce by crossbreeding resistant strains of white pine. These may tolerate as high or even higher levels of either type of pollutant gases than their parents.

The growing use of hydrocarbon fuels is causing increasing damage to coniferous trees both here and in Europe, putting an added and growing strain on our timber resources and threatening the recreation values of our forests in several areas. We have reason to suspect fume damage to evergreen species other than white pine.

We have strong reasons for being concerned with the effects of the ever-increasing output of powerplant and industrial stack gases on our forest acreage. This acreage is already under attrition from urban growth, superhighways, powerlines, new lakes, and other land uses. We must do far more than we are now doing in forest air pollution research to define and understand the full losses we are sustaining. (We can recognize readily only the more acute cases.) We must develop measures to prevent new kinds, as well as present forms, of air pollution damage to our forests which serve us with water, wood, wildlife, rangeland, recreation facilities, and many other valuable assets.

Arthur A. Atkisson. First, I was greatly impressed with the carefully reasoned approach taken by both Mr. Smith and Mr. Schwegmann. However, I did have the impression that the approach was essentially unidimensional. May I draw an analogy? Several years ago I bought a home in a

after, a hotrodder converted our front lawns into a racing path one evening. It seems to me that the repair of this damage was, in the terms of your paper, uneconomic to myself and to my neighbors. The indemnities to the parents of the hotrodder were also uneconomic, and yet an individual had unleashed upon his neighbors an instrument capable of causing nuisance and damage and, in strictly economic terms, the repair of this damage was probably not feasible at that time and in that place.

Is it not true that an industry or any complex of activities can enter a community and by the very nature of its operation can create a situation which, under the criteria posed by both Mr. Smith and Mr. Schwegmann, will elude control because it is uneconomic for either the community or the industry to pursue control? And if this criterion has a validity, as asserted in the paper, does it not also have a validity with the industrial planners who are even now planning the location, the expansion, and the revision of existing and new plants throughout the country? And should this not be placed high on the list of such planners, so that we don't create situations where control officials are faced with a choice between the preservation of values which are very difficult to price or with obvious economic consequences of some magnitude to individual property owners or the community itself?

Smith. You've described a fairly complex situation with the hotrodder example. I would say that it was not uneconomic to repair the damaged lawns as you did; in the frame of reference I choose to use, it was indeed the correct thing to do. The lawn damage had a very large economic weight in your system, it was an important feature of your environment, and I should think that there is no contradiction here with the industrial situation. I don't for one minute intend to imply that looking at everything through an economic eyeglass, as I was requested to do, means that we must soft-pedal any of our desires to have a better environment, a more healthful environment, or a cleaner environment. My only point is that all of these desires are not only reducible, but must be reduced finally, to an economic basis in order that we can take some kind of action. And as to the final question, a necessary economic judgment is made when a firm locates a plant and when it is decided what the effects of the plant on its surroundings will be. Then the correct

ranchers and the agriculturists in the San Francisco Bay area. At the present time, ranchers in the fruit business have a problem with disease in the fruit trees. Some infected trees have to be immediately destroyed and we are allowed to burn these. Also, the rancher who produces grain has a large crop of stubble left after the harvester leaves about 1½ feet of straw still standing, and we are allowed to burn it. This causes a great deal of smoke and, as members of the Air Pollution Control Board, we are worried that the time will come when this will have to be disallowed.

Speaking officially now for the Bay Area Air Pollution Control District, we urge the Federal Government, as a major financier of soil conservation practices and other agricultural subsidies, to do extensive agricultural engineering development for practical means of disposing of agricultural field wastes such as grain stubble, orchard prunings, artichoke tops, range brush and weeds, brussels sprouts, and tules. We also ask the Federal Government to require as a condition of financing that anti-air-pollution methods, to the extent that they are practical, be used by growers. We further ask that the Federal Government require all who purchase timber rights, lumber or soil-mill operators, to follow trash disposal or soil-mill refuse disposal practices that will not pollute the air. We realize we have a problem. We want to stop air pollution, but we must find some means of disposal that doesn't cause any smoke.

Middleton. This brings up another issue, one that others have also asked about. What is the effect agriculturalists are having upon agriculture by their destruction of wastes? Mr. McElroy, could you tell us about the influence that destruction of wastes, such as Mr. Gnoss mentioned, has upon agriculture?

John S. McElroy. In California we recognize two facts about air pollution and its relationship to agriculture: first, that agriculture does make a contribution to air pollution; and second, that we suffer a fairly tremendous loss in agricultural production as the result of air pollution. So we have been very much concerned. Through the extension service we have made a survey of the principal counties of the State as to their burning of agricultural waste products, which we classified as prunings of trees and vines, stubble burning, miscellaneous

burning (which includes the burning of various wastes around the farm), the cleaning of ditches and fence lines, and other disposal practices. We have worked very closely with the research people with respect to what these contributions and their effects may be. This study will be reported soon and I think it will give us some definition of the contribution of agricultural burning to the air pollution problem of California.

In the problem of disposal of wastes, we may have to turn from what we are doing to something else and to a considerable extent change some of the patterns of agricultural practice. We may have to place a temporary economic burden on the farmer which he is not, of course, going to like. But we've made a small start on the problem. However, the experiment station is working on equipment for the disposal of some of these wastes. Much is already known which, if it were practiced, would be a help. Gradually I think these things are becoming known and being applied. We attemped to measure the effects of burning according to the time of year and meteorological conditions and this may prove helpful.

But the point I wish to make is that in California, the University of California, for example, is aware of this problem, is beginning to work with it, and is beginning to show some promise of results. The Bay Area Air Pollution Control District has tentatively outlined a program of cooperation on burning of weeds between the district and the University of California, which has a great deal of knowledge concerning weed control.

J. J. Weinstein. What effects do the farmers' cultivation practices have on air pollution?

Rodenhiser. There's no question that they do have some effect on air pollution. However, I should like to point out that the situation over the past few years has changed rather radically with new methods of farming, and a considerable research effort is being put into just this particular problem of soil management. Unfortunately, from our point of view, with the changes in different types of agriculture in certain parts of the country, this seems to be a continuing problem. Not only are Agricultural Research Service efforts involved but also most land-grant college experiment stations include soil management research in their program.

Middleton. Two questions which deal with some of the remarks of Dr. Herring might both be phrased this way. What, if any, influence does the application of agricultural chemicals, including toxic pesticides, have upon community air pollution? Dr. Daines, perhaps you could answer this.

Daines. The workers in the agricultural experiment stations, the United States Department of Agriculture, and the industries are aware of the problems from the application of pesticides, whether sprays or dusts, but I think this is an area where much more information is needed. In New Jersey, we tell our farmers of such possibilities whenever it seems appropriate and we encourage them not to use highly toxic materials as dusts, but rather to apply them as sprays, so that the amount of air pollutants is at an absolute minimum. I think our farmers are in most instances following this kind of advice. When we talk to people who mix dusts, we encourage them to use heavy materials, so settling will be as rapid as possible. I should add that, as far as I know, materials that are very toxic to warm-blooded animals are not usually applied as dusts.

Howard A. Post. First of all, my impression from all the papers and discussion has been that air pollution in general is a local or regional problem that requires solution at a local community level. This is probably because local conditions and the effects of pollution and local needs and the ability to solve the problems seem to be unique to each particular situation. Dr. Middleton presented an excellent paper, I believe, and my impression is that he leans toward solution of pollution problems at the community level and he did say that adequate air conservation depends upon total community planning. In his last sentence, however, Dr. Middleton mentions national aspects and he clearly states that there should be national air quality standards, national control over motor vehicles, and strong national leadership in air conservation programs. I wonder, Dr. Middleton, what you had in mind as to particular programs and standards.

Middleton. I don't have any prepared legislative resolutions to present. I should like to point out, however, that the apparent conflict in the text which you ably detected exists because I used the State of California as my model. What I tried to do was to show that, as in California, there are other airsheds, creating other specific community problems, and it's quite certain from what Dr. Herring has reported that communities themselves can do something about these. Now for the question: What is the proper role of the Federal Government in these issues? Simply this, that there

standing of the adverse levels of designated pollutants; having different standards for different counties and different States is a ridiculous situation. There should be a sound basis for adequate standards and then these should be applied nationally. I urged Federal leadership in the sense that perhaps the Public Health Service, already deeply concerned with this problem, would know what the county and State problems are and could then, rather than dictatorially, say, "These shall be the standards for the United States," afford other States and communities the opportunity of having this information in order to do something about it, perhaps modifying it to accord with local circumstances. In essence, this would be my reply to your comment. Dr. Herring, do you have some comments that might be pertinent to Mr. Post's remarks?

Middleton. Well, we hope they would be uniform. The standards should have uniformity in value, but their applicability might not be uniform across the country. A standard for sulfur dioxide might not be pertinent for the State of Nebraska, whereas that standard might be highly pertinent elsewhere. I think the difference concerns the imposition of the standard once it had been determined.

Herring. Local communities would decide, for example, which parts of the standards were applicable to them?

Middleton. To some extent, yes. Give them the facts and I think one can count on their good judgment. I think it would be quite obvious that communities within any one airshed would have to have a common air quality requirement.

CONCLUDING REMARKS

IRVING MICHELSON
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During the past few hours we have examined several facets of the problems created by air pollution. Dr. Middleton directed our attention to the fact that air is a primary resource, and that man's dependence upon this resource imposes on him the need to protect it from contamination. Dr. Rodenhiser pointed out that pollution of air produces a wide range of deleterious effects on other vital resources—crops and livestock. Dr. Herring gave us a better understanding of how air pollution affects our use of still another fundamental resource—land—and presented a series of proposals on urban planning and development which would help avoid the air pollution problem in the future. All three speakers indicated that we have learned a great deal about these problems in the past few years, but they also made clear that there is still a great deal to be learned. There is no doubt that we are not yet aware of all the pollutants in our atmosphere, nor are we yet aware of all of their deleterious effects. What we have heard today was essentially a summary of the latest information available on the complex subject of the effects of air pollution on our natural resources of air, agriculture, and land.

During the same time that we have been discussing our subject, delineating the known areas and the research needs, three other panels have been busy doing the same things for related subjects. The four panels this morning have been laying the groundwork for this afternoon's panel discussions—we have been spelling out the problems, and this afternoon's panels will discuss the best ways to attack these problems immediately. Even though we know that our present knowledge and means are not the ultimate, even though research undoubtedly will lead us to greater understanding and more effective wait for ultimate solutions. We must do whatever we can now, attacking these problems with the latest knowledge and most effective means now at our disposal.

The morning panels have divided the problems into two parts. Two panels have been discussing the major sources of air pollution—motor vehicles, industrial plants, powerplants, and municipalities (including homes). The third panel and we in this fourth panel have been reviewing the effects of air pollution. The third panel has been discussing the effects on health; that is, the direct effects on man himself. On the other hand, we have been discussing the effects on man's environment, and we have seen that man's inhumanity to man's environment boomerangs to his own disadvantage.

Our panel is unique among all of today's panels in that, as an official part of our assignment, we have had to discuss ". . . Economic Considerations." Even though the word "economic" does not appear in any other part of the program of this conference, I should be very much surprised if the subject of economics did not rear its ugly head in every other session today, as it did yesterday. For, let us face it, economic considerations are a key question in air pollution control efforts. In fact, the effectiveness of our air pollution control effort will be in direct proportion to the economic consideration we give it.

As I have indicated, this panel's assignment on economic considerations may have been intended to have us discuss economic effects of air pollution, and not the broader question of economic feasibility of air pollution control. But since Dr. Smith and Dr. Schwegmann have centered their discussions on economic feasibility, let us pursue this matter a

trol. Even though this may be true for some marginal producers, very, very few firms have been put out of business or forced to move from a community by the imposition of air pollution controls, mainly because the community usually considers such possibilities and permits ample time for installation of equipment. Many thousands of firms have installed air pollution control equipment without any financial difficulty, and many thousands more can also afford to do so. It is also true that the imposition of control measures sometimes involves only better control of combustion processes, which results in fuel savings, and that sometimes the cost of control equipment does pay for itself in the recovery of valuable materials in effluents.

Though the relative frequency of savings or extra costs as a result of air pollution control is not known at present, Dr. Smith made the point that, whether we recognize it or not, "air pollution control measures are without exception the result of some kind of economic judgments," because, as he said, "decisions regarding air pollution controls must of necessity be based on economic considerations."

One cannot disagree with these facts of life. Dr. Smith went on to say that, since decisions on air pollution control are based on economic considerations, "there should be an awareness of the relative economics of any given situation," and that therefore "all other factors must be translated into economic terms." Finally, as a consequence of this reasoning, Dr. Smith has told us that the effects of air pollution on human health should similarly be expressed in economic terms, in order to give them "their correct relative economic weight," as part of the "complete spectrum of costs" which should enter into decisions on air pollution control programs.

Dr. Smith recognized that it is not easy to place a dollar value on health, and that he as an individual might object to an air pollution control official's possible decision that, in the light of a purely economic cost analysis, Dr. Smith's worth as an individual was insufficient to warrant any control action to protect Dr. Smith's health. In other tions of Dr. Smith's statements, because one can logically extend his argument to the conclusion that we should spend no money on air pollution control unless we can prove that whatever we spend is balanced by proven savings as a result. And if we were required first to prove the extent of money losses, all or most air pollution control programs would grind to a halt very quickly.

Dr. Smith has recognized this by stating that "a lot of differences in opinion on the principles involved lose their vitality when real situations are considered." I would venture to suggest that the reason that economic considerations seem to lose their vitality in real situations is that economic considerations are not the basic considerations; they are only the means to ends dictated by other considerations of a more human nature. Economic considerations, in the sense of balancing the cost of doing against the cost of not doing, certainly constitute a major basis for the operation of a business. It even may be proper for a business to consider the health of its employees in economic terms. But the millions of individuals who make up the public do not run their lives on such an impersonal businesslike basis.

For better or for worse, people do look at health matters in a nonbusinesslike manner. We all know of families who have spent all of their life's savings, and gone heavily into debt, to prolong the life of a member of the family, even for only a month or two, without any thought of recouping the tremendous expenditures involved. We all know of the efforts which communities exert to prevent a few children from locking themselves in abandoned refrigerators, to prevent a few people from contracting polio, etc., etc. No, in the matter of the health of an individual and the members of his family, the principle of balancing economic considerations is rarely applied.

People spend money to enjoy life, to make themselves more comfortable, to increase their satisfactions. It is toward these ends that people spend much of their money, with no thought of any monetary returns to balance expenditures. In these mat-

ters, as in the matter of health, people are different from business; their needs are different, and their attitudes are different. The Pittsburgh leader of air pollution control quoted earlier today by Dr. Haagen-Smit expressed this very appropriately, and it bears repetition: "Air pollution control in a modern city and in a mature city is built on a fresh concept of people living together in productive enterprise rewarded in terms of work and enjoyment."

Air pollution threatens man's comfort, his health, and the effectiveness of some of his activities. Where it affects his economic life, as in the case of agriculture, in which air pollution raises the cost of foods, or as in the case of land resources, in which air pollution depreciates land value and limits its uses, man should consider the economics of the situation; the question of balancing the cost of air pollution control against the economic losses incurred by not controlling the pollutants is quite pertinent. But in cases where air pollution affects man himself, his health, and his comfort, in any way, economic considerations are not the primary factors which dictate whether or not we should institute control of air pollution. There is no balancing of the costs of air pollution control against the discomforts and pains and illness caused by smog.

Of course, we want the control to be as inexpensive as possible, just as we want to get TV sets at as low a price as possible. And, of course, the prices may be more than we can afford, in some cases. It is precisely for these reasons that one of the primary goals of air pollution control research is to bring the effectiveness up and the costs down. But it is not true that we must achieve a balance of control costs against costs of noncontrol in all cases.

Rather, it is as Dr. Haagen-Smit stated it: "Control is always a balance between the desire of obtaining as clear air as possible and the price the community is willing to pay for reaching this goal."

Perhaps we can generalize all this by saying that a community will be willing to pay the necessary costs only when it is convinced that either the comfort and health of its inhabitants will be increased or their economic burdens will be eased. A keyword here is "convinced"—and this implies an educational process. It is therefore altogether fitting that this afternoon's sessions will include a panel on public information.

"Convinced" also implies that we have available the necessary facts with which to do the convincing. It is therefore also fitting that other panels will discuss the measuring of air pollutants and the available control methods.

Dr. Smith suggested that the facts presented to the public should include all the pertinent cost figures whenever possible, and he deplored the general practice of giving one-sided cost figures. He gave as an example the case of auto exhaust controls, in which the unit cost per car is often cited, but not the total for all the cars involved. Dr. Smith proposed that instead of telling people only that it may cost $100 per car for an exhaust eliminator, we should also tell them that the cost in the Los Angeles area would total about $300 million initially and millions more each year. This proposal seems quite reasonable, and I would like to take a minute to discuss the real impact which such a simple, innocuous-sounding proposal may produce when we follow through on it. One immediately obvious result would be to enable communities to compare alternative solutions; for example, the people in Los Angeles could then weigh the relative merits and costs of the auto exhaust eliminator program and an electric-powered public transportation system.

Dr. Smith's proposal should work both ways, of course. Let us apply it to the case of the burning of leaves in Detroit, which Dr. Smith also mentioned. He pointed out that officials of the city of Detroit have decided that the city cannot afford the estimated half-million dollars to have the leaves carted away instead of allowing them to be burned in the streets. Now, according to Dr. Smith's proposal, the Detroit City Council should tell the public not only the half-a-million-dollar total figure, but also that it would cost each of Detroit's 1,670,000 inhabitants only 30 cents per year to have the city get rid of the leaves. The citizens of Detroit might well acquiesce to paying 30 cents a head to eliminate leaf burning, if they understood the harmful effects of burning leaves, and if they had an opportunity to express themselves on the subject, particularly early in November.

I believe that the cost of the leaf burning in Detroit is an excellent example of the need to translate the costs of air pollution control into terms applicable to the individual citizen, the consumer of the polluted air. The individual citizen is not only the ultimate consumer of polluted air, he is also the one who ultimately pays the costs, whether it be in the form of higher taxes, higher prices of appliances and foods, or the cost of an exhaust eliminator on his car. He is entitled to know how

culture are abated, that he would have to paint his home less frequently and wash his car less frequently, that his clothes might last longer and look better; yes, even that he would not need to shampoo his hair as often.

Not only is the individual citizen entitled to know the relative costs of living with polluted air or clean air, but I am also convinced that such information could be very persuasive, purely in terms of economic savings which can be achieved by air pollution control in some cases. For example, if we were to inform the inhabitants of a community that each family is spending several hundred dollars per year in extra cleaning and maintenance costs alone because of air pollution, and that most of this sum could be saved by investing less than $5 per family per year in an air pollution control program, it might well rally public support for air pollution control. I am aware that most attempts to rally public support by this means have failed in the past, but I strongly suspect that a reason for the past failures is that we really do not know the actual costs involved. We can only give vague "guesstimates" at present, and these are hardly convincing; we need hard, cold facts in this area, if we wish to persuade people to take appropriate action.

A pilot study started in 1960 by Consumers Union indicates that the added personal costs to families living in polluted air are difficult to assess, but that the difficulties are surmountable. Without going into details of either the assessment or the difficul-entation was in the form of suggestions for future planning of urban areas so that residential sections can be relatively free of air pollution. Inherent in her paper is an exposure of the many dreadful mistakes man has made in building his present cities. Her proposals are so fundamental and far reaching, and so attractive, that we must approach our present problems with a deep sense of guilt that these problems are a result of our past mistakes, our past inaction, our past thoughtlessness. It is especially frustrating to realize that these principles can apply immediately only to newly developing areas, that we cannot apply these principles to our present cities except in a very slow and incomplete way unless we suffer the kind of sudden changes which engulfed Rotterdam, Stalingrad, Frankfurt, and Hamburg 20 years ago. Would that our ancestors had had the benefit of Dr. Herring's proposals, and had chosen to utilize them. We must not make the same mistakes again, and Dr. Herring's blueprint should be a valuable guide for newly developing areas.

Meantime, we must still face up to the consequences of our past mistakes: we must deal with our present problems of air pollution in our present urban areas, even if the measures we must use may seem to be only temporary palliatives by Dr. Herring's standards. Let us conclude this panel session with a resolve to work out realistic and effective methods of conserving our resources, utilizing all our know-how, at this conference.

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Panel E

APPLYING OUR MEASURING AND MONITORING KNOW-HOW

FAIRCHILD AERIAL SURVEYS

Know-How to Air Pollution Control

Chairman: GLENN R. HILST

Co-Chairman: MOYER D. THOMAS

Reporter: RAYMOND SMITH

Participants

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INTRODUCTORY REMARKS

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Hartford, Conn.

In introducing the topic of this session, "Applying Our Monitoring and Measuring Know-How," I should like to take a few minutes to set in perspective the problem of applying that know-how to the solution, or at least the partial solution, of our air pollution problems. To do so, let me offer a somewhat irreverent paraphrase and near-inversion of the Biblical injunction for practical brotherly love, namely, "Cast thy wastes into the atmosphere and they will probably show up in unexpected places and in unexpected forms." And we may add, somewhat parenthetically, "and cause unexpected results."

The key word here is "unexpected," implying as it does our lack of complete knowledge of the complex system of sources, atmosphere, and receptors which comprise this problem of air pollution. If we knew the space and time dependence of all sources of air pollutants, the atmospheric transport and diffusion of these materials, and their interaction with each other or other indigenous materials, then we would have no need for measurements and monitoring of air pollution levels. They would be precisely predictable and, supposedly, controllable to tolerance levels.

We do not have this knowledge now; pollutants do show up in unexpected forms and places and produce inexplicable results. And yet, if we are to maintain a reasonable degree of control of air quality, it is essential that we have basic information as to what the forms and levels of air pollution are and what they have been. Why? Because without this information we are totally in the dark in assessing the magnitude and form of our air pollution problems and we cannot even begin to grapple with the problem of what must be done to keep pollution levels within tolerance limits. Incidentally, these measurements are just as necessary and useful in determining that we do not have a pollution problem as they are in showing that we do.

For some pollutants, such as malodorous gases, eye irritants, and visibility-reducing suspensions, the human senses are effective qualitative measuring devices and, along with human physical and psychological responses, quickly tell us if an air pollution problem exists. There are other pollutants which defy detection by human senses and call for instrumental measurements. Perhaps the best known of these are ionizing radioactive materials. In either case, we generally try to achieve an objective, quantitative measure of pollution levels so that we can attach numbers to this problem. Implicit in this approach is the underlying assumption that the air pollution problem is a deterministic one, susceptible to quantitative cause-and-effect relationships in part and in toto. On the basis of what we know now, I will venture the opinion that this is true; that is, for given source and atmospheric conditions there is only one distribution of pollutants, although this applies only to fairly long periods of averaging, say for 24 hours or more. For shorter periods of averaging we may, in fact, be dealing with a probabilistic problem, in that a whole range of pollution distributions is permissible for a given set of conditions.

I introduce this thought because it has an important bearing on how we design our pollution sampling or measuring system, a problem I hope will receive some attention here this afternoon. However, regardless of this point, measurements of air pollution levels are fundamental to the definition of our air pollution problems today and to any program designed to control air pollution levels. They are both fundamental and, at least

Recognizing this basic requirement for air pollution measurements, a whole host of questions regarding the amount and use of this information remain to be answered. To what degree of completeness must we determine the time and space variability of air pollution levels in an urban area? Is one measurement site sufficient for control purposes? If not, how many are required? Recognizing the large variability of pollution levels due to the diurnal cycles of sources and to atmospheric dispersion properties, how frequently must we sample the air to properly define pollution levels? What materials should we measure? How well can we measure them? To what extent should air pollution measurements be designed to assist in clarifying the roles of pollution sources and atmospheric dispersion in the pollution system? Who should have responsibility for making these measurements? For their evaluation and interpretation? How can these measurements be best used to develop and enforce control measures on air pollution levels?

It is to these and similar questions that we address ourselves this afternoon. They are not simple questions and definitive answers may not be forth- ... and valuable guides to the use of measuring and monitoring know-how in the control of air pollution today can and will emerge. It is implicit in the title and subject matter of this Conference that we can do useful and practical things to control air pollution now and in the near future. It is necessary and desirable for us to recognize also the things we cannot do, and continue to reduce the number of those things by effective research and development. But in the meantime, we need not wring our hands in despair.

In summary, continuing measurements of levels for various air pollutants are essential to the definition of the magnitude of our air pollution problems and to the effectiveness of our control procedures. The information derived from these measurements, taken in conjunction with knowledge of the effects of these pollutants and their sources or genesis, provides us with incomplete but useful tools for maintaining tolerable levels of air pollution concentrations now.

It is with real pleasure that I now call upon our distinguished speakers and discussants to develop this topic of applying our measuring and monitoring know-how to clearing the air.

THE NEEDS, OBJECTIVES, AND CAPABILITIES OF AIR POLLUTION MEASURING AND MONITORING PROGRAMS

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I. INTRODUCTION

In step with the rapid expansion of population and industrial activity in the United States, there has been a concomitant increase in the volume and complexity of community waste products—solid, liquid, and gaseous. The gaseous wastes pose a special problem since they cannot conveniently be stored for subsequent disposal under more favorable conditions, as in the case of some liquid and solid wastes. Gaseous effluents in general must be released at their point of origin as fast as they are generated.

The atmosphere, because of its immense volume and ubiquitous nature, is a logical medium for the disposal of airborne waste products. Paradoxical as it may seem, however, the capacity of the atmosphere for this purpose is not unlimited. Within recent years many communities have frequently witnessed the phenomenon in which the rate of pollutant emissions exceeded the ability of the air to dilute and disperse the pollutants. The result has been intense atmospheric pollution with all of its attendant undesirable and, in severe cases, lethal effects.

There are certain communities such as Los Angeles where, because of its population density and industrial activity as well as meteorological and topographic factors, the dilution capacity of the atmosphere is exceeded quite regularly throughout the year. When these conditions prevail, the concentrations of air contaminants become high enough to cause annoyance to the senses, economic damage, and actual or suspected injury to health.

A logical objective of an air pollution control program is the attainment and maintenance of an atmospheric environment of sufficient purity to prevent discomfort, inconvenience, illness, and hazards to personal safety and possessions. Perhaps a more realistic goal would be the guarantee of air quality such as to promote better health and well-being of persons, animals, and vegetation. This implies a condition of air cleanliness in which concentrations of significant pollutants are kept below those levels at which adverse effects can occur.

Quite obviously then, a basic need in air conservation is a program for the measurement and identification of air pollutants. Fundamentally, the problem of air pollution represents the interactions of three variables, namely, a source of emissions, the atmosphere which acts either to dilute or concentrate airborne concentrations, and sensitive receptors—animal, vegetable, or mineral. A rational program of abatement must be based on a thorough knowledge of the nature and interrelationship of these three factors. A complete air measurement and monitoring program must include provisions for the systematic collection and analysis of data on the type, number, and strength of polluting sources; the influence of the meteorological and topographic variables; levels of air contaminants; and the type and magnitude of measurable effects on man and his environment.

II. AIR POLLUTANTS, EFFECTS, AND METHODS OF MEASUREMENT

The basic question arises, what pollutants should be measured? Virtually any solid, liquid, or gaseous substance which is not a component of normal

1. Corrosive and toxic gases: Sulfur dioxide, hydrogen sulfide, oxides of nitrogen, carbon monoxide.	Material damage, vegetation injury, health effects.	Gas scrubbers, indicator tubes, automatic analyzers, test specimen (plants, materials, and treated papers).
2. Suspended particulates:		
A. Nonspecific	Dust nuisances.	Filter papers; inertial, thermal, and electrostatic precipitators; test specimen.
B. Toxic dust, fumes, and mists: Lead, fluorides, sulfuric acid.	Vegetation injury, health effects.	
C. Pollen and biological agents	Health effects.	
3. Dustfall	Soiling nuisance	Jars, trays, adhesive films.
4. Visible smoke	Soiling, sky darkening, visibility reduction.	Ringelmann chart, transmissometer.
5. Odors	Nuisance	Human observer panels.
6. Photochemical pollution: Hydrocarbons, oxides of nitrogen, ozone and other oxidants, aldehydes, aerosols, etc.	Photochemical smog effects: Eye irritation, vegetation injury, reduced visibility, and rubber cracking.	Gas chromatography, flame ionization, spectrophotometers, rubber strips, human observer panels, test plants.
7. Radioactive gases and aerosols	Contamination of materials, health effects.	Same as for items 1 and 2 above, and radiometric instruments and techniques.

air is a potential pollutant. Thus the list of candidates is almost inexhaustible. Over the years, however, research and experience have uncovered many specific substances which are of hygienic importance. Doubtless, continued progress in air pollution research and investigations will yield many more pollutants of significance. The contaminants and effects to be measured depend upon the nature of a particular problem. Each air monitoring program must be geared to the needs and resources of the individual community.

Table 1 represents an attempt to list some of the more commonly occurring pollutants of recognized importance. Also included in this table is a listing of the more obvious potential effects from exposure to the selected pollutants. The last column indicates some of the methods generally employed for atmospheric sampling, analysis, and measurement.

The table is intended merely as a guide, since details of specific methods of sampling, analysis, and measurement are beyond the scope of this paper. For additional information the reader is referred to the many excellent reports by Federal, State, and local air pollution agencies; professional societies; and private and university research laboratories. The two-volume treatise entitled "Air Pollution" recently published by the Academic Press contains many valuable technical details on methods and techniques.

III. OBJECTIVES OF AIR POLLUTION MEASUREMENTS

As previously indicated, a program of air pollution measurements and monitoring is basic to the conservation of our air resources. Objectives of air measurements fall into two broad categories. The first of these can be termed surveillance.

A. *Surveillance*

A program of surveillance can serve a number of very useful purposes. Continuous air monitoring data help to establish short-term patterns of air pollution concentrations, diurnal or seasonal, as well as long-range trends. Information of this type is also useful in evaluating the efficacy of control measures in existing air pollution abatement programs, and in the prediction and prevention of large-scale air pollution disasters.

1. *Monitoring Networks*

Constant surveillance is the key to a successful pollution abatement program, both from the standpoint of day-to-day control operations and from that of air pollution disaster prevention. Within the past 7 years several air monitoring networks have been established at the local, State, and National levels.

Local

The Los Angeles County network consists of 14 stations, each of which collects and reports information on as many as 6 key contaminants and such effects as eye irritation and plant damage (*1*). Six of these stations continuously monitor four contaminants as required by the disaster prevention program. Many other cities likewise operate local networks.

Statewide

On a statewide basis, Montana is operating a network of seven air monitoring stations in an attempt to determine the cause of high lung cancer rates in counties where there are many smelters and wood-waste burners.

New Jersey operates 35 monitoring stations gathering data on the soiling properties of the atmosphere, in order to categorize communities on the basis of air cleanliness.

Other States operating sampling networks include California, Maryland, Massachusetts, New York, Texas, and Washington.

Nationwide

(*a*) *National Air Sampling Network.*—By far the best known and most comprehensive air monitoring program is that of the National Air Sampling Network conducted by the U.S. Public Health Service (*2*). It had its modest beginning in 1953, and today includes 250 representative urban and nonurban sampling stations operating on the basis of every year or every other year. This is a voluntary cooperative program in which the communities contribute the manpower needed to operate the samples, while the U.S. Public Health Service provides the sampling equipment and supplies, performs the analyses, reduces the data, and publishes the results.

There are two phases to the National Network—the sampling and analysis of suspended particulate matter, and the measurement of gaseous pollutants. The main objectives of the NASN are to determine in general the extent and nature of air pollution in the United States, to study the trends in concentrations of selected pollutants in the air, and to investigate the interrelationship beween air pollution and local factors such as topography and meteorology, population density, and the industrial complex. Network data are also useful in epidemiological studies, selection of sites for new facilities, and planning and zoning.

The particulate sampling equipment consists of a high-volume blower drawing about 45 cubic feet of ambient air per minute through an 8- by 10-inch filter paper made of fine glass fibers. The efficiency of this material is extremely high for particles as fine as one-seventy-five thousandths of an inch. A 24-hour sample is obtained every other week on a random time basis. Collected samples are mailed to the Public Health Service Robert A. Taft Center in Cincinnati where they are subjected to a thorough analysis.

The determinations made on the samples include total weight of particulate matter, organic fraction, beta radioactivity, nitrates and sulfates, and as many as 23 metals such as antimony, bismuth, cadmium, vanadium, zinc, and others. The detailed results and findings of the National Air Sampling Network are contained in two voluminous reports, one published in 1958 and the other released just before this conference (*3*, *4*), as well as other publications (*5*).

About 2 years ago the scope of this network was increased to include measurements of gaseous pollutants. About 45 of the network stations collect gaseous samples along with particulate samples. Currently being monitored on an experimental basis are sulfur dioxide and nitrogen dioxide by means of specially designed sampling kits consisting of plastic bubblers connected through critical orifices and membrane filters to a pump (*6*).

(*b*) *Continuous Air Monitoring Program*—To supplement the NASN operations, about 1 year ago the Public Health Service, in cooperation with State and local agencies, initiated a program of continuous gas monitoring in six of the largest metropolitan areas in the United States (*7*). Included in this program are stations locally operated in three other cities. By means of sensitive automatic instruments, the air is monitored on a continuous round-the-clock basis for six gaseous pollutants. Each automatic gas analyzer makes a continuous record of the pollutant concentrations on a strip chart. In addition, the same information is punched out on a digital tape readout, each entry representing the average concentration over a 5-minute period.

The punched tapes and other records are sent to the Taft Center, where the data are processed by means of an electronic computer which yields statistical summaries of pollutant levels. These data, along with weather observations, will supply valuable information on air pollution patterns and

The off-site radiological monitoring program in connection with testing of nuclear devices at Las Vegas is designed, in part, to protect inhabitants of the surrounding areas from the potential radioactive fallout hazard.

3. *Los Angeles Alert Program*

In Los Angeles, because of public concern that air pollution may reach intensities high enough to produce a London-type disaster, an alert program was established in 1954 by the Air Pollution Control District (*1*). An air sampling network continuously monitors four specific pollutants—ozone, sulfur oxides, nitrogen oxides, and carbon monoxide. Alert stages have been designed for each pollutant in accordance with table 2.

TABLE 2.—*Alert Stages for Toxic Contaminants (p.p.m.)*

Contaminant	Alert stages		
	1st alert	2d alert	3d alert
Carbon monoxide	100	200	300
Nitrogen oxides	3	5	10
Sulfur oxides	3	5	10
Ozone	.5	1.0	1.5

Los Angeles County Air Pollution Control District (*7*).

The purpose of this system is to prevent the excessive buildup of air contaminants to levels which may cause a general catastrophe. The plan includes provisions for declaration of alert stages, and shutdown of rubbish burning, vehicular traffic, and industrial activities according to the alert level reached. It is interesting to note that since 1955 about 45 alerts have been called, but no second or third alerts. Most of these were called within the first 4 years. In the last 4 years there has been an average of only two alerts per year.

4. *Forecasts of Air Pollution Potential*

For the past 2 years the U.S. Weather Bureau research station at the Robert A. Taft Center has been conducting an experimental program of forecasting weather conditions conducive to intense air

station. Such prior notification of stagnation periods enables air pollution research and control agencies to make special observations in their area, and constitutes a mechanism for alerting local control officers to potentially heavy air pollution conditions.

B. *Surveys, Investigations, and Research*

The second objective of air measurements relates to the conduct of surveys, investigations, and research studies aimed at characterizing the air pollution problem.

1. *Surveys*

Air pollution surveys cover a broad spectrum of types and objectives (*8*). One type is useful in evaluating local source problems involving specific and identifiable emission sources, such as an aluminum reduction plant, a steel mill, or a cement plant, in order to determine the effect of particulate and gaseous emissions on the surrounding area. Another type of survey can yield information useful to the selection of a site for a new industry. Collection of data on current air pollution levels and future trends is a valuable tool in community planning and zoning. Unfortunately, this procedure, as well as site selection surveys, is seldom practiced, consequently many opportunities to prevent needless and undesirable situations and litigation are lost.

2. *Air Pollution Appraisal and Short-Term Study*

Another form of air pollution study is the appraisal. Many of these have been conducted since the enactment of Public Law 159 in 1955, on a community or statewide basis, by Federal, State, local, or private organizations. The vast majority have been performed with the assistance and support of the Public Health Service. The purpose of such air pollution appraisals is to determine the current status of air pollution in a community or group of communities, to estimate future potential for air pollution intensification, and to offer broad recommendations for prevention or abatement. The findings and recommendations are based largely on existing data relative to population, industrial activity, combustion practices, and local climatology. Among the latest of these studies is

one described in a report entitled "A Pilot Study of Air Pollution," Providence, R.I., released June 1962. Another is described in a Public Health Service report entitled "Air Pollution in the National Capital Area," published in July 1962.

Another variety of this type of survey of limited scope and duration is the short-term air pollution measurement study. Studies of this type have been conducted in five cities with the cooperation of the Public Health Service (*9*). In general, they are based on an intensive air sampling and measurement program conducted "around the clock" for 7 consecutive days. The objectives of these studies include the development of preliminary information on air quality in the community studied and the enlistment of public interest and support for an air pollution program.

3. *Community Air Pollution Investigations*

The most comprehensive and detailed type of studies are the community air pollution investigations which involve considerable effort and expense in terms of air sampling and analysis, source sampling, meteorology, and effects. A good example of this variety is the aerometric survey conducted in Los Angeles County from August to November 1955 (*10*). This was an intense campaign of air sampling and measurements which utilized a network of the stations operating daily. The pollutants selected for study were oxidants, oxides of nitrogen, hydrocarbons, carbon monoxide, sulfur dioxide, aldehydes, and airborne particulates. Simultaneous observations were made of eye irritation among panel observers, of plant damage, of visibility, and of meteorological variables.

This study yielded definitive information on the distribution of photochemical air pollution and related effects according to time and geographical location throughout the Los Angeles Basin. The conclusions derived from this study were of invaluable assistance in the subsequent planning and execution of the abatement program of the county air pollution control district. Another interesting illustration of a comprehensive communitywide survey is the 2-year special air pollution study of Louisville, Ky., completed in 1958 (*11*). It was conducted by the Public Health Service in cooperation with State and local public health departments, air pollution control agencies, and private industry.

Briefly, the study was aimed at determining the origin and nature of the air pollution problem affecting the West End, a residential area of Louisville adjacent to a large industrial complex. The investigation included collection of original data on air pollution emissions, atmospheric concentrations, climate and meteorological variables, and pollution effects. The final report, which appeared in two parts—a summary and a technical report—contained a detailed inventory of pollution sources and emissions, comprehensive data on air quality and its variation with time and location, information on the responses of observers to varying types and levels of air pollution, and recommendations for abatement and control (*12, 13*).

4. *Research Studies and Special Investigations*

(*a*) *Nashville, Tenn.*—Research studies and special investigations represent an important source of new knowledge needed to cope with the complex and burgeoning problem of air pollution. The Nashville Community Air Pollution Study completed in 1959 by the U.S. Public Health Service and Vanderbilt University provides a rare example of a large-scale community survey designed to study the relation between air pollution and chronic or long-term effects on health (*14*). This was a 1-year medical-engineering study of the character, extent, and effects of air pollution in a typical Midwest coal-burning community. The medical phase consists of detailed morbidity, mortality, clinical, and autopsy studies. The prime objective of the engineering phase was to provide comprehensive air-quality data for correlation with medical findings. Employed in this study was a most elaborate aerometric network consisting of a total of 123 air sampling and meteorological stations arrayed in a uniform pattern throughout the urban area. Air concentrations were determined by a variety of methods on monthly, daily, 2-hour, and, at a few stations, continuous bases. The voluminous aerometric data were programed for analysis on a large electronic computer. Although the results are still being analyzed, preliminary medical findings indicate that adults residing in areas of high sulfur oxides pollution suffered higher asthmatic attack rates than those residing in areas with low sulfur oxides pollution. Explanation for these findings, as well as others yet to be reported, must await completion of this study.

(*b*) *Seward, Pa.*—Another research study in which accurate information on air quality is a critical requirement is one presently in progress in Pennsylvania under the joint direction of the U.S.

to high levels of pollution from a soft-coal-burning powerplant, while the other is almost completely spared. Medical and engineering assessments are being made to determine whether there exist significant differences in health status between these communities, and if so, whether they can be correlated with air quality measurements.

(*c*) *National Atmospheric Lead Study.*—Lead is a common air pollutant. Because of the fact that (1) it has toxic properties, and (2) its concentration in urban atmospheres is increasing, the Federal Government, local agencies, and private industry are currently collaborating in a joint study to obtain definitive information on concentrations and trends of atmospheric lead in selected urban areas (*15*). In addition to air sampling at a number of representative locations in Philadelphia, Cincinnati, and Los Angeles, samples of body fluids from persons residing in these areas are being simultaneously collected and analyzed to determine the body burden of lead among individuals in various age, sex, and socioeconomic groups. In addition, the study seeks to ascertain whether changes in atmospheric lead levels are reflected in body fluid lead levels. Data from the Philadelphia area show that persons living and working downtown have higher blood and urine lead levels than those in a comparable group living in the suburban area. Generally, men had higher blood levels than women, while smokers showed higher levels than nonsmokers. In no case, however, were the concentrations found considered abnormally high.

(*d*) *Effects of Motor Vehicle Emissions.*—Within the past few years there has been an increase in interest in the possible health effects of motor vehicle emissions (*16*). With financial support provided by the passage of the Schenck Act in 1960, the U.S. Public Health Service has initiated and sponsored a number of research projects in this important facet of air pollution. In a study just begun, a group of experimental animals at Wayne State University in Detroit is being exposed to air piped in from a nearby thoroughfare carrying heavy automotive traffic. A similar group of animals breathe purified air. The purpose of this study is to determine what bodily changes occur in the animals exposed to air contaminated with auto exhaust, in comparison with the control animals. A parallel study recently got underway in central Los Angeles.

target or objective for air cleanliness (*17*). Ambient air standards provide such a goal, since they represent the maximum allowable concentration of specified contaminants which can be tolerated in the atmosphere without producing undesirable effects on man and his surroundings. Once this goal is attained, it is possible to establish emission standards defining the maximum allowable rate of discharge of contaminants from the source. The combination of air quality criteria and emission standards comprises a logical basis upon which to promulgate sound and equitable regulations for prevention of pollution and conservation of the air resource.

The establishment of criteria is virtually impossible without such information as data on discharge rates of specific pollutants, atmospheric concentrations, meteorologic data on days of varying air pollution intensity, and knowledge of the relationship between pollutant concentrations and specific effects.

The air quality and emission standards recently established in California represent a pioneering effort at controlling community air pollution in the United States on the basis of sound philosophy supported by reliable and accurate measurement data.

IV. NEEDS AND LIMITATIONS OF AIR MEASUREMENT PROGRAMS

A. *Air Monitoring*

While a considerable amount of effort is being put into air measurements and monitoring programs by Federal and State agencies, there is a need for increased activity at the local level. Since control of air pollution is a local responsibility, it is logical for each community to assess and survey its own problems.

In many air sampling networks programs there is only one sampling station for each community. Recent studies have shown that it is unlikely that one station can yield measurements which are representative of the entire community. Additional sampling points are needed to depict an accurate picture of pollution in a given city. Further knowledge is desirable on optimum frequency and duration of sampling, and number, distribution, and physical characteristics of sampling sites.

B. *Instrumentation*

Factors which limit the regular collection of source and air quality data are the relative lack of comparatively simple, reliable, accurate, and inexpensive instruments for the continuous and automatic sampling and analysis of air contaminants (*18*). While a few types of sophisticated devices exist, their cost and complexity place them beyond the reach of most communities. This is likewise true of meteorological instruments. Hand or grab sampling methods are expensive in terms of manpower. In addition, extended sampling periods yield average concentration figures which deemphasize significant peaks occurring outside of normal working hours.

C. *Techniques*

Satisfactory methods and techniques exist for a large variety of pollution measurements. However, many procedures are complex and time consuming. In addition, methods for measuring some contaminants and effects are either inadequate or completely lacking. Procedures for analyses in depth are presently quite limited. Examples of these are visibility and plume opacity evaluations, continuous analyses of particulates in stacks, odor determinations, and eye irritation assessments. Greater efforts should be made to achieve adequate and uniform methods for a larger number of diverse air pollution measurements.

D. *Aerometric and Source Data*

Although the results of the National Air Sampling Network are published and made generally available, air-quality information independently collected by the communities themselves is not always published. By pooling the resources of governmental and private organizations it may be possible to establish a central repository of air-quality information. Such data could be cataloged and made accessible to control officials, industrial management, research, teaching and consulting organizations, and others in the field of air pollution.

The lack of information on source emissions is even more acute. In a rapidly changing technological society such as ours, a dynamic program for the systematic collection and dissemination of emission data would be highly useful. Such information likewise could be handled on centralized repository basis.

V. CONCLUSIONS

Although there are still many unanswered questions about air pollution and its effects, it is quite clear that atmospheric pollution represents a heavy economic burden to this country, and that it can precipitate or aggravate many kinds of respiratory diseases (*19*). There is no justification for postponing our best efforts in combating this problem. With few exceptions, there exists today adequate means for evaluating local air pollution conditions and for sharply curtailing emissions. Since community air pollution is increasing at an alarming rate, it would be a serious mistake to delay positive, constructive action until all the complex questions are answered.

Knowledge of sources, atmospheric concentrations, and effects is germane to an equitable and effective air conservation program. While the criteria will vary according to the specific situation, atmospheric measurements and air monitoring constitute an essential phase of any air conservation program. This applies to a vigorous ongoing program as well as to one which is in the early stages of planning or development.

Current air monitoring and measurement practices indicate a need for greater participation on the community level, improvement in technique and instrumentation, and a freer exchange of air quality and emission information.

In man's never-ending quest for a better and safer environment, constant vigilance to protect our most vital air resources is a necessity as well as a responsibility.

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Prepared Discussion: NEEDS, OBJECTIVES, CAPABILITIES, AND LIMITATIONS OF AIR POLLUTION MEASURING AND MONITORING PROGRAMS

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It is a pleasure to have this opportunity to discuss Dr. Rossano's paper and to add a few observations to the views he has so capably expressed. There is little in this paper to which I would take exception, although I should like to discuss certain aspects of the subject in a slightly different light.

Dr. Rossano has pointed out that an effective and sensible air pollution control program—local, State, or national—can not be set up unless the facts are known. We must know what is in the air and how much and what the harmful or objectionable nuisance, health, or damage effects are. All shades and degrees of these effects exist, and so there are certain to be honest differences of opinion. However, with the accumulation of masses of data, the picture should come into focus.

The general objective, then, of air pollution measuring and monitoring programs is simply stated as: "to learn what substances are in the air and how the amounts vary." The first question to be answered is this: "Are the right things being done and are the programs adequate to yield the needed information within a reasonable time?" The summary of surveys, investigations, research studies, and networks, which is a major part of Dr. Rossano's paper indicates that a great deal is being done in measuring and monitoring air pollution. However, I must agree with his statement that more activity is needed at the local level.

The National Air Sampling Network of the U.S. Public Health Service has done much to excite local interest in learning more about the air pollution problem. The NASN, although designated as a network, actually serves less as a network than as a means of providing information to some 250 local sampling areas. For the most part the data developed in one community have little significance in terms of the information from samples taken at other locations. The NASN, then, provides equipment and analytical service to States and municipalities which these areas are not yet in a position to furnish to themselves. As State and urban air pollution control agencies become better equipped with manpower, laboratories, and know-how, one would assume that the NASN could be considerably reduced or discontinued. The time should not be too far away when national studies and surveys of air pollution can be carried out using test data from local control agencies.

The air sampling networks and monitoring programs of States, control districts, and municipalities are increasing in number and capability and should ultimately make available the data needed for their control of ambient air quality. It is in these smaller areas that sampling networks can give integrated pictures of community air pollution situations. With the responsibility of control in the hands of local and State governments, the agencies of these governments must have the backing of technical information on harmful substances in the air before they can make sensible decisions with regard to their abatement and control.

The extent to which a city is able to monitor its ambient air for pollutants is limited by funds available and, of course, also by its scientific know-how. One response to this situation has been to conduct surveys with outside help. Such periodic surveys, supplemented by special sampling and testing

Large industrial plants usually do not publicize their air pollution monitoring programs; however, such programs are quite common. In addition to automatic air sampling and testing equipment located at corners of the plant fences and at appropriate neighborhood points, plants will often have miniature weather stations to record such meteorological data as wind direction and speed, temperature, humidity, and atmospheric pressure. The information collected not only makes possible better control of air pollutants, but should an objectionable air pollution incident occur, it is evidence to all concerned of desire and effort on the part of the plant management to avoid such inadvertencies.

Whereas the importance of community air sampling programs is generally recognized, there is little consensus as to how these programs can be carried out most effectively and economically. There are few experts in this field. The proper initial step would seem to be an identification and evaluation of the harmful effects of air pollution in the community. This is difficult because significant health effects of urban air pollution have not been clearly established and a survey to determine such effects for a particular community is very expensive and time consuming.

Nuisance effects are more easily measured because the human being is the sampling and analyzing device. This method, however, lacks standardization and calibration and cannot be depended upon to give results of consistent accuracy and meaning. There is great variability among communities with regard to tolerance of odors, smoke, and dustfall.

The air pollution control agency finds it necessary to set down the objectives of its control program in more or less arbitrary terms, not necessarily related to the harmful or the objectionable effects of the ambient air concentrations in its jurisdiction. Corrective steps have been those directed toward reduction or elimination of nuisance effects. Such steps, will, of course, provide a cleaner, more healthful city atmosphere, and we all like to breathe clean air.

If it were possible to draft ambient air quality standards which describe air purity, cause no objectionable effects, and are attainable at reasonable cost, the problem of the control agency would still analysis on a routine basis is very expensive. If there is inadequate data and uncertainty, the agency will be inclined to "play safe" by imposing unreasonably restrictive and costly control limits.

When is air pollution monitoring adequate? I don't think there is a simple answer. The amount of sampling and analysis will always vary from city to city depending upon the seriousness of the air pollution situation and upon the amounts of money appropriated for the program. It is paradoxical that a community which has spent much money in setting up a program for routine sampling and analysis of its atmosphere is able to find little if any reliable information to show whether or not the levels of pollutants found may be having harmful health effects. Nevertheless, monitoring is important to all large cities, to show not only current levels, but also the trends for those air contaminants which are near critical concentrations.

It has been reported that, of the 10,000 or so communities in the United States, no more than a few hundred at most are making regular determinations of particulate or gaseous pollutants, or both. This is a small percentage of the communities but a much larger percentage of the population of the United States. When one considers that today nearly all of our large cities have control programs and have at hand fairly accurate figures on the ranges of the more important pollutants in their atmospheres, it appears that a sound foundation has been and is being laid for protection of urbanites from harmful air pollution. It is in these large cities that the greatest potential problem exists.

Air pollution survey and control programs have been activated in many States through State agencies. These agencies have worked to assist smaller communities which have air pollution problems. When a small community has a major air pollution problem, it is usually a result of a few large and obvious sources which, when controlled, leave little reason for other than spot checks of ambient air in the community.

In his conclusions, Dr. Rossano does not discuss needs, objectives, and limitations of monitoring programs; but rather gives a warning of the possible effects of increasing air pollution and a plea that communities get busy on a program to learn the nature and extent of their local problems.

upward or downward in levels of various pollutants. Since health effects of specific pollutants are not established, these programs, as used today, mainly produce useful information on levels of so-called nuisance pollutants, such as particulates, or those that cause odors, eye-smarting, or visibility reduction. Correction of nuisance effects does not depend so much on the expensive collection of masses of data on ambient levels of pollutants as it does on knowledge of sources and control problems. It is safe to say that the regulatory agencies of all large cities are cognizant of the major sources of nuisance pollutants in their areas and are aware of the problems of correction. The extent to which community air pollution must be measured and

1. Appropriate and adequate air pollution monitoring programs should be maintained in all large cities and in certain other communities where surveys have shown objectionable air pollution potentials to exist.

2. Continuous air sampling and analyses for a considerable number of pollutants are very expensive and for most communities cannot be expected to yield significant information beyond that obtained by so-called spot checks.

3. The Public Health Service is doing a commendable job of providing services, training, equipment, and know-how to States and communities to enable them to assess their air pollution problems and to follow trends in pollutant levels.

ASSIGNMENTS OF RESPONSIBILITY FOR AIR POLLUTION MEASURING AND MONITORING ACTIVITIES

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Nearly everyone contributes to air pollution. It is necessary only to look around you in any community to see that this is true. The individual members of the public contribute by the operation of private transportation, by home heating, and by trash burning. Municipalities, which are organized by the public to take care of the many problems involved in living together, contribute to air pollution by refuse disposal practices, sewage treatment, power generation, operation of public transportation systems, and steam generation. Industries add to the pollutional load as a result of manufacturing and processing the thousands of items used in our modern civilization, including fuels, metals, chemicals, paper, synthetic resins, and building materials. Commercial activities add to the load by steam generation, transportation, shipping, and power generation. Agriculture must also be included because of the contribution from land clearing, insect control, frost protection, weed control, composting, and feeder-lot operations. All of these activities contribute gases, vapors, dusts, mists, and fumes to the atmosphere. If atmospheric conditions are satisfactory and a moderate load is placed on the air resources, few problems will result. However, if meteorological conditions are not favorable or the atmospheric dispersal capacity is exceeded, air pollution problems may result.

The Bay Area Air Pollution Control District uses a popular definition of air pollution which could be paraphrased: Air pollution is the presence in the atmosphere of materials put there by the acts of people in such concentrations that they interfere with people, the things people own, and the things people like to do. It will be observed that the previously listed groups are made up of people who not only contribute to air pollution but also are the ones who are affected by air pollution. The individual members of the public are aware of air pollution because of possible health hazards, eye irritation, materials damage, nuisances, inconveniences, property devaluation, and esthetic deterioration. When people organize into a municipality, we find that this entity experiences the effects of air pollution as a result of materials damage, property devaluation, esthetic deterioration, complaints, and the cost of enforcement of air pollution control ordinances. Industries notice that air pollution may damage structures, interfere with production, damage their products, add to their financial worries by the cost of control, and result in public relations problems. Air pollution interferes with commercial activities because of materials damage, damage to structures, and visibility interference. Agriculture is affected mainly by vegetation damage and hazards to animal health.

All of the activities which have been mentioned, and a number of others, not only contribute to air pollution but also are affected by it. Thus each has a measure of responsibility for bringing such pollution under control. Since sampling and analysis are at the very heart of air pollution control, each has also a measure of responsibility for those functions. Before the assignment of responsibility can be made, however, it is necessary to evaluate

what needs to be done in the area of measuring and monitoring. In air pollution control activities, a number of items might be sampled and analyzed. The attitude of a population regarding a nuisance condition might be evaluated. Vegetation is frequently analyzed for airborne damage. It might be desirable to determine the concentration of a given contaminant in a neighborhood or in an industrial stack. It might also be essential to measure the effect of some polluting material on humans and animals or to obtain information about meteorological variables. The main reasons for conducting measuring and monitoring activities are: (1) to establish the existence of hazards in the environment, (2) to determine the efficacy of ameliorating measures, and (3) to appraise whether contamination is from a special process or other source. Establishing the presence of hazardous conditions in the environment is usually accomplished by ambient air sampling. In some instances it may be necessary also to add vegetation sampling to the program. The appraisal of contamination from a process or other source may involve ambient air sampling, vegetation sampling, stack sampling, and obtaining meteorological data. Frequently it is also necessary to obtain background information about the various contaminant levels when the sources are either inoperative or not yet existing; for example, background meteorological data are particularly important when selecting a site for a new process which may discharge polluting materials into the air. All of the measuring and monitoring activities that have been mentioned require technical skills of a variety of disciplines, including engineering, chemistry, statistics, meteorology, and others. All of them involve the problems of handling vast quantities of data, analyzing them, then preparing and disseminating the necessary information. This requires skills in addition to those already mentioned. Another area which touches on all of the measuring and monitoring activities is research into methods. For many contaminants and many situations, satisfactory methods are available and can be used with success. For other contaminants and specific situations, new or improved methods need to be developed. Much time is spent in operating agencies on research or development activities in the area of sampling and analysis. A certain amount of this type of work is probably unavoidable to meet specific problems as they develop. However, research agencies should devote more of their time to such developmental activities. An area of investigation which needs a great deal of work is the measurement of economic factors as they are affected by air pollution. At the present time little or no methodology is available for evaluating the economic effect of polluted air as applied to agriculture, materials, property, and general nuisances.

All of these activities, and many others, come under the heading of measuring and monitoring activities. The problem to be decided here is who is best qualified to do the things that need to be done. Any assignment of responsibility to organized groups in a general manner presupposes that these groups have personnel technically qualified to handle the job. However, there may be factors other than technical qualifications to be considered. Ability to finance, special knowledge, interest, and organization to carry out the activities, all fall into this category. Spokesmen for industry frequently propose that industry should be made responsible for control of its own air pollution. This has not worked, for several reasons. Not all air pollution is created by industry, and there is frequently a difference of opinion as to whether or not the air is being polluted. Thus, control activities usually are conducted by the people through their organized units of government at the local, State, or Federal level. The philosophy is generally accepted that any control activity should be handled at the lowest level of government capable of doing the job.

Each of the groups mentioned previously has a role to play in the measuring and monitoring activities which support a control program. Municipalities as used in this discussion include counties, cities, and various combinations of these groups which might be formed to combat air pollution. The municipalities are on the front line of air pollution control. Theirs is the primary responsibility for measuring and evaluating the status of air pollution in their community. It would be desirable for all communities to have an existing agency or a person to serve as a watchdog for the onset of air pollution problems. With a relatively small expenditure, a preventive program could be set up in communities which could forestall the development of serious air pollution problems. Unfortunately, preventive programs of this type are seldom popular with the public or with politicians. Thus, the first action in air pollution control is usually taken when conditions occur which cannot be explained on any other basis and which someone suggests might be due to polluted air. The municipality usually consults with the State university, the

State health department, or a consulting firm for help with its problem. After the initial advice is obtained, the community officials must decide how they will combat the problem. This usually involves setting up an agency whose responsibility is air pollution control or adding air pollution control to an existing agency. If the problem is relatively simple, the monitoring program suggested, and perhaps set up by the first consultant, can be continued by a small staff, with the results analyzed by others. Most air pollution problems do not turn out to be this simple, however. If it appears that restrictive ordinances are essential, a preliminary survey must be conducted which would involve emission inventories, ambient air sampling, and collection of meteorological data. The municipal program needs to define its objectives early. The staff must have an appreciation of what needs to be done and the limitations on what can be done. It should be recognized, for example, that one high-volume air sampler, which may be a part of the National Air Sampling Network, will not describe the air pollution situation in the community, and that community supplementation will be necessary. In fact, it may turn out that a high-volume air sampler is not the most satisfactory device for sampling in a given community problem. In general, the municipality must carry out those sampling operations which are essential to provide background information and then permit evaluation of the progress of the control program. If an ordinance is in effect, the municipality must do compliance testing. This testing may involve sampling of stacks, of the ambient air, of vegetation, of meteorological variables, and of many other factors. The municipalities also have the responsibility of citing the need for, collecting, and properly utilizing, the funds which are necessary. Air pollution control is expensive. It requires trained personnel and, in many instances, elaborate equipment. Larger municipal organizations should have the capability of conducting the most complex sampling and analytical programs. Many existing control districts have this capability, while others in communities of equal size and with equally severe problems do not have the capabilities. Small communities may need assistance in all but the simplest measuring and monitoring problems.

The State government agency responsible for air pollution control should be prepared to provide the necessary preliminary technical assistance to communities which do not have the resources for carrying out complex sampling programs. The State agency should assist local communities in the establishment of air pollution control activities when necessary. In order to carry out this function, it should have a capable staff of limited size, a limited amount of routine sampling equipment, and a supply of more complex equipment. The State agency should not be relied on for this function after the municipality has established its own program, except in the case of complex problems. If the community does not wish to establish a continuing program, it should have the work done by contract. In addition to preliminary aid to municipalities, the State agency should have personnel who are qualified to assist the municipalities in their more complex problems. Engineers should be available who have a knowledge of various process industries; meteorologists should be available to aid the municipalities in interpretation of meteorological data; and physicians should be available who have experience in some of the health problems associated with polluted air. State agencies have a function in addition to their aid to municipalities. Some air pollution problems occur in areas of the State where local government units cannot, or will not, assume responsibility. In these instances, monitoring and measuring activities must be carried out by the State. In addition, the State agency should maintain a statewide surveillance network which is tied in at one end to the municipal networks, and at the other to the National Air Sampling Network. One new activity which could be inaugurated in many States would be a central data-processing and information center. Vast quantities of data are obtained in monitoring activities, especially if recording instruments are used. In any given State, very few of the municipal control programs could support a modern computer. However, a statewide computer center could provide data reduction for the State program as well as for municipal programs. Data transmitters, utilizing existing telephone circuits, could be used to connect each municipality with the center. There are some problems which the State should not be expected to be able to handle and for which assistance may be needed.

To provide the most up-to-date data and information on a variety of air pollution problems, the Federal Government, through the Public Health Service, should act as a clearinghouse for all types of technical information. It has technical experts who can provide advice on the most complex monitoring problems. Much of this information is de-

veloped in local programs, and other local programs can benefit by the Federal collation of data from all over the world. The Surgeon-General's Ad Hoc Task Group on Air Pollution Research Goals has concluded that a great expansion is necessary in the support and stimulation of research into survey techniques, the development of methods and procedures for sampling, and the development of the subtle measuring techniques necessary in studies of physiological function. Most of this research support is recommended at the Federal Government level. Isolated instances occur where ultra-complex problems arise or air pollution problems arise as a result of Federal Government activity. An example of both of these is to be found in some of the activities associated with nuclear energy. In these instances the Federal Government program should provide the knowledge and support for monitoring programs. One area where the Federal Government has been active and should continue to be active is in the support of activities intended to train the highly specialized personnel necessary for air pollution control activities. The universities of the Nation should have the responsibility of training the professional environmental health specialists essential to the control programs, but the Public Health Service must continue the intensive training of technicians and the "retreading" of professionals in air pollution sampling and analysis. In addition to assistance to the States and municipalities, and the support of training and research activities, the Federal Government has a basic responsibility for nationwide evaluation of air pollution. This function has been carried out through the mechanism of the National Air Sampling Network, which has given a reasonable picture of conditions throughout the United States. Unfortunately, the data many times are misused, but this is not the fault of the system. Recently, the network was expanded to include gas sampling in nine urban stations. The gases which are sampled include: carbon monoxide, sulfur dioxide, total oxidants, total hydrocarbons, nitric oxide, nitrogen dioxide, and ozone. After experience with these stations has proven the program to be sound and the instruments reliable, the Continuous Air Monitoring Program needs to be expanded.

Not all of the load, either financial or technical, should be borne by Government agencies. Industry and commerce must cooperate in the performance of the work as well as in planning procedures and methods. Each industry should know more about its processes and problems than any Government agency. Thus, the cooperation of the industry with the control agency is invaluable in helping to develop standardized procedures and methods. In Florida, the phosphate industry and the State Board of Health have worked together in the development of stack sampling procedures which take into consideration some of the conditions which are peculiar to some of the phosphate processes. In another instance, the laboratories of every one of the companies located in the phosphate-processing area participated with Government laboratories in a joint study of methods of fluoride analysis. The results of this study were used by the State Board of Health in preparing standard sampling and analytical procedures. In another instance, a company which planned to locate in Florida began the accumulation of meteorological data for use of the design engineers, some 2 years before the design was to be completed. Data were furnished to both the State and local agency charged with air pollution control. Each industry should also know more about the possible sources of contaminants in its processes than any outsider. Further, they have an economic interest in the functioning of control equipment which has been installed. Thus, much stack and source sampling should be done by the industry itself. This is for its own information as well as to assist the program of air pollution control in a community. Because of the distrust of industry motives by some members of the public, it is usually desirable to have control agency personnel participate in the sampling. Numerous instances are available where agency and industry teams work side by side and split samples for analysis. Cooperation by an industry in the measuring and monitoring program not only makes available technical skills which otherwise might not be available and reduces the financial load of tax-supported activities, but also provides opportunity for good public relations. A further very important contribution of industry, either alone or jointly with others, is the publication of much of the measuring and monitoring information which is presently in its files. At one time, this information was classified because of the existence of a particular problem, but in many instances the need for continuing the classification no longer exists. Much valuable data presently are gathering dust in the files of industry which could be used for the benefit of all.

Three other groups outside of government and industry have a role to play. The first of these is

composed of the several technical associations whose interests are directly related to air pollution control. These associations play a very active part through their publications. The committee organization, which is an integral part of any association of this type, can and does assist in the development of methods of sampling and analysis. At the present time, the Manufacturing Chemists' Association, the Air Pollution Control Association, the American Industrial Hygiene Association, the American Conference of Governmental Industrial Hygienists, and the American Association for Testing Materials have published methods of sampling and analysis. These organizations should continue this activity but it is hoped that their work can be coordinated and that all can cooperate in the publication of a manual of methods for air sampling and analysis. An intersociety committee is presently active, and there are high hopes for success. A manual of this type would be invaluable to control agencies. The associations can serve two other functions, in providing unbiased advice and in serving as a forum for resolving technical problems in measuring and monitoring. Private consultant groups also have a role to play in measuring and monitoring programs. As mentioned previously, private organizations are frequently consulted during the initial stages of the development of an air pollution control program. The consultants can provide contract services to government agencies and industry. Of course, not all consulting groups have capabilities in all types of air pollution. Thus, selection should be made on the basis of the experience and capabilities of the consultant. The consultants are especially valuable when an intensive measuring and monitoring program will not be necessary on a full-time basis, or where qualified personnel are not immediately available to the control agency or cannot be justified. At the present time, some universities are active in the area of measuring and monitoring. When these activities are connected with research programs or the development of methodology, they logically fall within the university function. The major functions of the university, however, are research and teaching. Thus, at such time as sufficient trained personnel and adequate control programs are available, university staffs should no longer engage in routine measuring and monitoring activities.

Second, agricultural groups can play an important role in the measuring and monitoring program by defining the conditions under which various types of vegetation are injured. This is a rather complex problem, but much has been accomplished in some instances. It is possible that vegetation itself may be used as a monitor in those instances when agricultural scientists have defined the relative sensitivity of various plants to various pollutants. The agricultural scientists have also been in the forefront in developing methods of analysis for various insecticides and pesticides. Such analytical procedures can be applied to those air pollution episodes in which these chemical compounds might be involved.

Finally, on the individual members of the public descends the ultimate responsibility for air pollution control programs, including the necessary measuring and monitoring activities. The public determines the need for control, it limits the extent of the program, and eventually, it pays for all activities, whether conducted by industry or government. Very few individual members of the public have the technical skills to recommend or conduct programs of their own. Very few have the financial ability to support measuring and monitoring programs on their own. Most successful air pollution control programs have been carried out in large communities. The size of the community, however, is not insurance of success in air pollution control. In most instances, the difference between a large city which has a successful program and one which does not is public interest. The interest and stimulation of the individual voter will largely determine the success or failure of air pollution control in the community.

Prepared Discussion: THE LOGICAL ASSIGNMENTS OF RESPONSIBILITY FOR AIR POLLUTION MEASURING AND MONITORING ACTIVITIES

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SUMMARY

There is no single logical system for assigning responsibilities for air pollution measuring and monitoring activities. Instead, there are a number of different types of logical patterns that need to be evaluated in each situation to determine its most practical assignments of responsibilities, considering the needs and the available resources. The responsibilities include determining when *no additional* measuring and monitoring are needed before positive control regulation and action.

*   *   *   *   *

In discussing Dr. Hendrickson's fine, practical, broad-ranging paper, I have chosen to present some generalized patterns with examples drawn from various experiences.

Where: The first pattern, which is operational, is based on the question, "Where do we measure and monitor?"

The general answer is "anywhere that will furnish information to guide work to 'Clear the Air.'"

More specifically, we take pollutant samples in a stack and at the stack outlet; we make sample "observation" measurements of the exhaust stream before it reaches the ground; we take pollutant samples near the ground within a few hundred feet of a small source or a few thousand feet from a massive source; we take pollutant samples miles from major sources and in the midst of hundreds of minor individual sources; we also take samples and make observations of materials that may be affected and make observations and measurements of people who may be affected nearby and at distances from specific large sources. We analyze some of the pollutants and affected materials and people in the location where they were sampled. Most analyses, however, are made at distant laboratories and clinics.

What: The next pattern, partly covered in "Where," is based on the question, "What is measured and monitored?"

The general answer is "potentially controllable pollutants, affected materials, and affected people." We also measure and monitor some natural or other practically uncontrollable pollutants, such as sea spray and desert duststorms and other environmental factors, such as solar radiation and gustiness, in order to be able to identify controllable pollutants and their undesirable effects.

More specifically we measure and monitor:

Large dusts and large droplets that fall out nearby. The taller the stack and the stronger the wind, usually, the farther they travel.

Microscopic dusts and droplets that are caught in aerodynamic downwashes, but that also remain suspended and may travel for hours and for miles.

Directly polluting gases that are disturbing usually only in the form in which they are emitted, such as hydrogen sulfide, which is malodorous and is damaging to leaded paint, to leaded metals, and to leaded porcelain enamel.

Indirectly polluting gases, which are usually innocent in the form in which they are emitted, but become disturbing only after reacting in

the atmosphere with sunlight and/or with other gases, such as the reactive hydrocarbons in the gasoline vapors that are emitted during the filling of an underground gasoline station storage tank, and the filling of an automobile fuel tank.

Double-acting polluting gases which are disturbing in their emitted form, and then, after atmospheric reaction, are disturbing in their new forms. Ethylene, from incomplete fuel burning or incomplete rubbish burning, is one example, because it can damage some vegetation at 5 parts per billion parts of air, and then after a sunburned gas reaction with oxides of nitrogen and sulfur dioxide (SO_2), forms new gases and microscopic droplets which cause a different type of vegetation damage, eye irritation, visibility reduction, and health impairment for some people who have a chronic respiratory disease.

How: The question, "How do we measure and monitor?" is the basis for the next pattern.

Generally we try to use highly reproducible and representative sampling procedures. We also try to use highly reproducible analytical procedures, so that we can have data that are as representative of the real situation as possible, practically.

Specifically, we try to obtain samples of specific air pollutants or specific groups of air pollutants in such a way that they are representative for the desired period of time and the site or area. We also try to obtain samples or observations of affected materials or people that are truly representative of all of the groups that were exposed to the pollutants.

We use instrumented measurements, where practical, that require a minimum of human memory or judgment, such as numerical tape punches or chart markings, although needle-dial face readings are usually considered fully acceptable. There tends to be less reliance on trained visual observations of microscope tissue and cell patterns, unaided visual observations of markings on vegetation, metal corrosion, paint damage, plume opacity, or visible range. There is often a reluctance to accept trained observations of malodorous effects, eye irritation, and chest constriction. Nevertheless, the trained eye and the trained nose are extremely useful in evaluating gross air pollution sources without needing to use expensive instruments.

The widest range of instrumentation and other sampling and observation methods are employed, some of them only recently developed for national defense and the space sciences. They either measure an undesirable pollutant, an undesirable group of pollutants, or an undesirable effect of the pollutants. Occasionally an identifiable characteristic is measured that may not, by itself, be an undesirable effect but is one that has been so well correlated with the pollutant(s) or the undesirable effects, that the characteristic serves as an index. Thus, on the west coast, the oxidant index value, measured by the KI method, usually correlates well with eye irritation from sunburned gases. But it is believed by some that in some parts of the midwest and the east coast, the oxidant index does not serve well because the higher SO_2 pollutant concentrations reduce the oxidant index number without changing the eye-irritating pollutants from the sunburned gases.

Why: In answering the question, "Why are measuring and monitoring done in the field of air pollution?" we come closer to our final pattern.

The generalized answer could be stated: "To provide to people who have responsibilities information that can serve as a current or later basis for decision for air pollutant control action or inaction."

More specifically, measuring and monitoring are done—

By a plant or other owner to learn if he is conforming to a voluntary or legally compulsory community standard.

By a plant or other owner to learn what degree of cleanup he should provide for.

By a plant or other owner to learn whether his control equipment supplier fulfilled his sales contract.

By an equipment installer to guide his design work and to assess his success.

By a control agency to assure conformance to legal requirements.

By a control agency to learn what added control regulations are needed.

By a research or other study group to establish correlations between levels of air pollutants and levels of undesirable effects.

By an engineering development group, to assess the control effectiveness of a new design.

By a property owner or other person who is being adversely affected by air pollutants.

Who: The answer to this question, "Who now does measuring and monitoring work in air pollution?" brings us closest to the final patterns called for in the title, "The Logical Assignments of Re-

sponsibility for Air Pollution Measuring and Monitoring Activities."

As we have already seen, any individual or any type of group can do, and to varying degrees now does, air pollutant measuring and monitoring. Almost everyone has a responsibility to do some amount and kind of measuring and monitoring as an emitter of air pollutants:

From his oil-burning jalopy.

From his smoking department store incinerator.

From his nuclear power reaction.

From his steel mill.

From his crop duster's "drift."

Almost everyone also does some kinds of air pollutant measuring and monitoring as a victim of air pollutants when he—

Observes the smoke, charred paper ash, and odorous gases from the poor incinerator in the apartment house across the street.

Observes the grime collected on his windshield as the car stands parked outside at work during the day or at home during the night.

Observes the restricted visibility shutting off the hills and tall buildings 10 or 20 or 30 miles away, in the absence of fogs or low clouds or desert dust storms.

As a specialized producer of sensitive vegetation or as a producer or user of precision equipment, monitors the inside air after it has been reasonably well cleaned when it was brought in from outdoors. This differs from totally-inside-generated-and-contained atmospheric pollution analysis, such as was needed in the classic case of photochemical smog in a long-range submarine.

As a classroom student or as an adult amateur-scientist, carries out air monitoring projects independently or as a cooperator with the local air pollution control agency or some other research and study group.

I believe the ethical or philosophical responsibilities are best stated in the official position of the board of directors of the Bay Area Air Pollution Control District, December 8, 1962, reproduced eleswhere in this book.

Because air pollution control is a "science and art of the practically achievable," it is recognized that the ethically and philosophically logical responsibilities just outlined are subject to a give and take in practical arrangements that accommodate the varying capabilities of small groups and large ones with varying economic, technical, and political capabilities.

An attempt was made to develop a "capabilities" table listing the purposes of measurement and monitoring (the Whys) down one side, and the responsible groups (the Whos) across, with notations as to the generally available practical capabilities. However, the listed factors turned out to be inadequate in complexity, based on experience, and so the table was not completed. The possible table X is presented in its incomplete form so that it may serve as a general guide for anyone who wishes to analyze his own specific community situation.

The smallest owners, without skilled staff people, usually expect to receive some degree of measurement and monitoring free from the local control agency. This is always forthcoming without disagreement if it is limited to something as simple as a trained inspector's plume evaluation rating. Nevertheless, several control agencies require that the owner provide his own means of knowing when his operation emits a dense plume.

Similarly, a small air pollution control agency may not be staffed so that it can run a beryllium or fluoride or even an SO_2 check of the neighborhood around a probable source. Such a small agency may, for such special purposes, call upon a local consultant or a nearby specialized group, such as another larger local agency, the State or university, or some other nearby specialized study group, to assist it for a fee or cooperatively, in exchange for access to related information that can be used to supplement the cooperator's training or studies.

The Bay Area Air Pollution Control District law provides that the Air Pollution Control Officer can require an owner to furnish a registered professional engineer's report on the air pollution emissions at the owner's expense. In addition, the control officer can send in a registered professional engineer of his own choosing, at the district's expense, to carry out a stack-sampling and other pertinent measuring and monitoring work. This has provided the district with evidence of violation of District Air Pollution Control Regulations, as well as information that is used to guide the development of new Regulations. There have been unresolved discussions between officials of different air pollution control agencies as to whether it would be proper to authorize a control agency to do a stack sampling of an operation at the agency's own determination, and then charge the owner for the full

Possible Table "X".—*Generally available capabilities for measuring and monitoring air pollutants*

	Small owner's staff	Large owner's staff	Small control agency's staff	Large control agency's staff	Skilled public agency's staff	Research group's staff	Consulting engineering staff
A. Conformance to established regulations:							
1. Visible emissions	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Source tests	No	Yes	(?)	Yes	Yes	(?)	Yes
3. Atmospheric tests	No	(?)	(?)	Yes	Yes	Yes	Yes
B. Effects evaluation:							
1. Vegetation	No	(?)	(?)	Yes	Yes	Yes	(?)
2. Soiling	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Corrosion	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Annoyance to senses	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5. Health impairment	No	(?)	(?)	(?)	(?)	(?)	(?)
C. Study for new regulations	No	Yes	Yes	Yes	Yes	Yes	Yes
D. Studies for new process developments and for new effects research	No	No	No	Yes	Yes	Yes	Yes

costs of the tests. As of this date, it appears that this is not usually politically palatable.

One of the Bay Area Air Pollution Control District's Regulation 2 provisions that has attracted considerable attention is a requirement that an owner whose operation emits sulfur dioxide in concentrations (regardless of volume) greater than 2,000 parts per million parts of exhaust gases, must provide a continuous ground-level monitoring installation at his own expense, and make full reports to the district control officer regularly. The monitoring installation must consist of three continuous sulfur dioxide measuring and recording machines and a recording wind direction and velocity unit. This regulation provision, enacted in 1960, was based on the undebated recognition of the undesirable localized direct effects of sulfur dioxide, above certain concentrations and exposure time periods, on vegetation and people. This provision has no relationship to any possible effects of massive emissions of sulfur dioxide in the later formation of visibility-reducing areawide effects after photochemical or other atmospheric reactions, which were in 1960 highly debatable and are still, though to a lesser extent, controversial. Such requirements for ground-level monitoring and official reporting by the owner of an operation are also used by the Federal Atomic Energy Commission and have, at times, been used in other special situations by courts and other legal bodies such as the International Joint Committee and the world tribunal at The Hague in connection with the Trail, British Columbia, smelter whose air pollutants caused vegetation damage in the United States. The use of ground-level monitoring, as contrasted with stack emission sampling, to guide the adjustments in an owner's air pollution emissions, is called "shipmaster control" because the owner has to "keep an eye out for the weather."

There is an increasing use of air pollutant emission and air pollution effect performance standards in land use planning and zoning ordinances, as well as in private covenants in organized industrial districts and industrial parks. This has intensified and extended the interest and activities of more private land developers in air pollution measuring and monitoring, because their own lease and sales contracts are directly involved.

In closing, it should be pointed out that there are examples of almost every type of air measuring and monitoring operations, responsibilities, and interests, not only in Florida, as described by Dr. Hendrickson, but also in several other areas, including Los Angeles. We also find this in the San Francisco Bay Area done by private, by semipublic, and by public groups at all levels of ownership and government. State, Federal, regional, and local government agencies do monitoring in a number of cooperative relationships, including regulatory, research, and student training. Semipublic research and educational groups also do measuring and

monitoring, usually in cooperation with the government groups. Private corporations do measuring and monitoring for a number of reasons, ranging from self-regulation to defense against possible unjustifiable damage claims. Private citizens, including professionals in related fields, also do some measuring and monitoring because of their interest in obtaining cleaner air in the community.

The development and subsequent adoption and publication of standardized measuring and monitoring methods by competent groups will to some extent decrease the skills and costs now required and should thus enable more people and groups in the future to obtain and disseminate information that can be used to support judgments by responsible groups for decisions for action to "help clear the air."

It must be made clear, however, that for each type of air pollutant there is a broad range of specialists and specialized techniques available. Similarly, for each type of detrimental air pollutant effect there is another, somewhat overlapping, broad range of specialists and specialized techniques available, even including specialists in the fields of individual and social behavior when, for example, there is a need to determine the malodorous effects of some pollutants on people residing in an exposed area.

MEASUREMENTS AND MONITORING KNOW-HOW

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It is not the purpose of this paper to deal with sampling techniques for specific sources of emissions, since such sampling would generally be used to augment an air pollution control program rather than to determine the type of program which should be available in a community. The remarks herein will be confined instead to the general sampling of the atmosphere through the use of inexpensive, readily available devices, and the utilization of resulting information to develop approaches to an air conservation program planned as a companion program to one aimed at the control of direct nuisances.

Many larger communities today find themselves able to deal with the direct nuisance problem in which there is a specific, individual source of pollution, and some rather direct social or economic effects on adjacent inhabited areas. While such programs may eliminate many sources of complaint, they seldom are capable of providing the community with an overall air quality of a desirable nature. It is, however, to this problem of appropriate air quality, through what I refer to as air conservation programs, that our attention must be directed.

Air conservation programs which are initiated today will not have appreciable effects on community air quality until 5 to 10 years from now. There is ample evidence to indicate that, during those 5 to 10 years, our air quality will be increasingly downgraded, with an accompanying buildup of public hysteria and clamor. The haste in decision and injudicious action which can result from such pressure will certainly, in the end analysis, cost infinitely more than the immediate application of existing measurement and monitoring know-how to the problem of improving the air we breathe.

It is the author's personal opinion that in the field of measuring and monitoring, as in most other fields, there has been a tendency to revert to overprofessionalism. This tends to make the layman, as well as the professional, throw up his hands at the complexity of the problem, and lapse into the do-nothing ivory tower based on the premise that we must have perfect knowledge. The desire for perfect knowledge is a goal. We do ourselves and our communities a vast injustice if we allow action to await its attainment.

I believe the following will show that we do have available simple guidelines through which reasonable, long-range objectives can be delineated. Such objectives are capable of periodic reevaluation as our knowledge and techniques improve. I firmly believe that such readjustment will be far less costly and otherwise less detrimental to our communities than a failure to begin, even if imperfectly.

Abraham Lincoln once said, "If we could first know where we are and whither we are tending, we could better judge what to do and how to do it." This simple philosophy is fundamental to our approach in providing the community with an air conservation program. We must first define the present quality of our air, both geographically and temporally. Admittedly, most communities lack the resources to make such a definition with respect to all contaminants. An assessment, however, of certain ones which can be measured will tend to give us some idea of how the others may vary. Such a theorized understanding may be wrong in part, but it will seldom be as totally wrong as the guesses made in the usual vacuum of no information whatsoever on anything. In figure 1, you will note the network of sampling stations employed in Philadelphia. While some of these stations are relatively sophisticated, most employ only such simple monthly integrating devices as lead peroxide candles for comparative levels of oxides of sulfur,

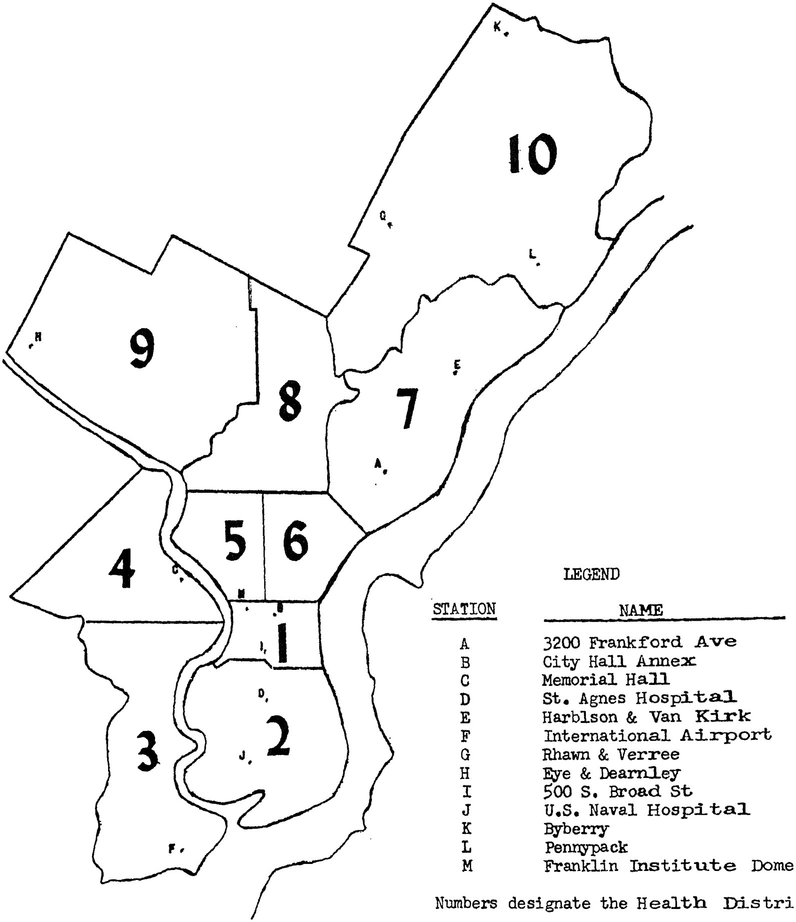


Figure 1

Map of Philadelphia by health districts with the location of each sampling station in the air monitori program

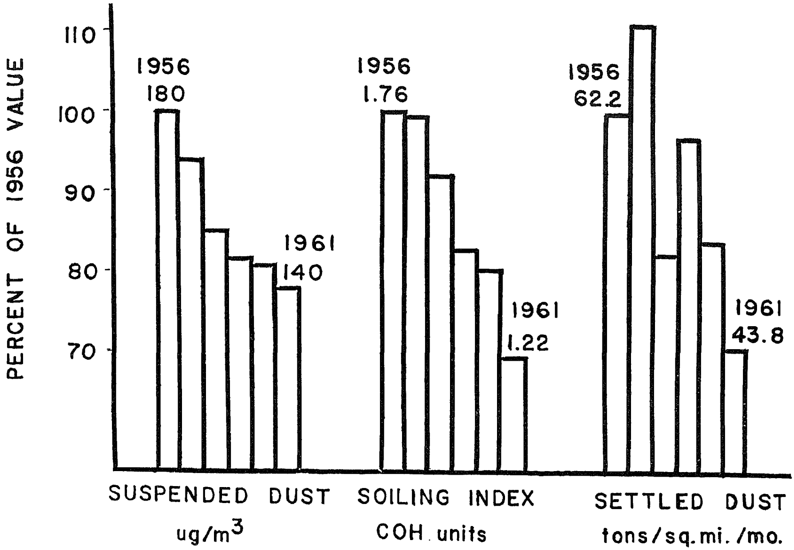


Figure 2
Trends in dust content of Philadelphia air, 1956 to 1961 data

and dustfall jars for the monthly measurement of settled dust. Some stations have augmenting devices, such as American Iron & Steel Institute (AISI) samplers, and high-volume samplers for airborne dust. All of these devices are inexpensive. The analytical procedures employed are comparatively simple. The results can be rather startling.

You will note in figure 2 an assessment of Philadelphia's dust problem from 1956 to 1961. Two things have been provided herein. One is a baseline level of community dirt; the second is a judgment of how effective our program has been, or to what extent community factors tending to generate dust have altered. In time, we expect to see these bar graphs turn upward, not because of any diminution of effort on our part, but because of increasing pollution potential in surrounding suburban areas. This brings us to another reason for applying our present know-how. It is one of the few available devices for selling the need of control throughout common-use air basins.

In figures 3, 4, and 5, you see an assessment of the geographic distribution of three pollutants throughout the community area. These maps, for the first time, enable us to point out areas in need of program emphasis, and the influence of one area on adjacent ones. Furthermore, they enable us to indicate to the residents of the so-called cleaner areas that, while they may not be troubled with direct nuisances, their air, at some time during the year, reaches levels of dirtiness consistent with those found in areas normally thought of as being quite dirty. The skeptic may immediately say we cannot possibly define precisely with so few sampling stations. In this, he is correct; but the picture is based on reasonable information, and it is sufficiently correct to provide the desired working knowledge for the enforcement program.

The existence of these maps has generated considerable interest in doing similar mappings of the entire Delaware Valley area, with the obvious thought that such information will be of immeasurable help in zoning, and area planning. For the first time, therefore, through the availability of some information, the concept of planning with respect to the air resource has been introduced.

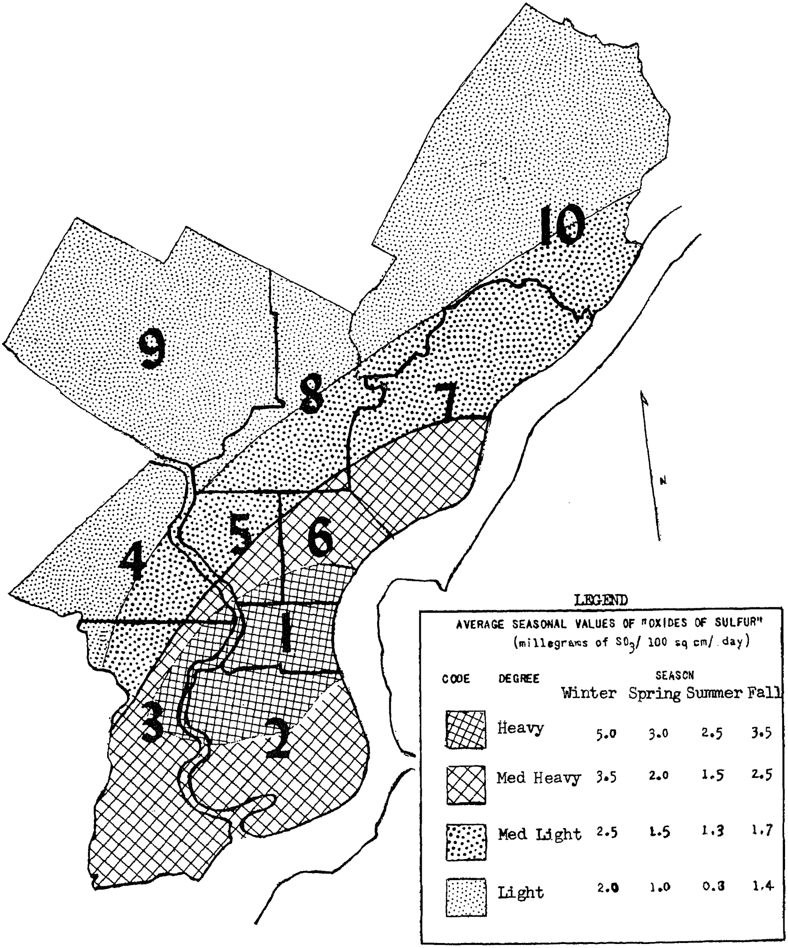
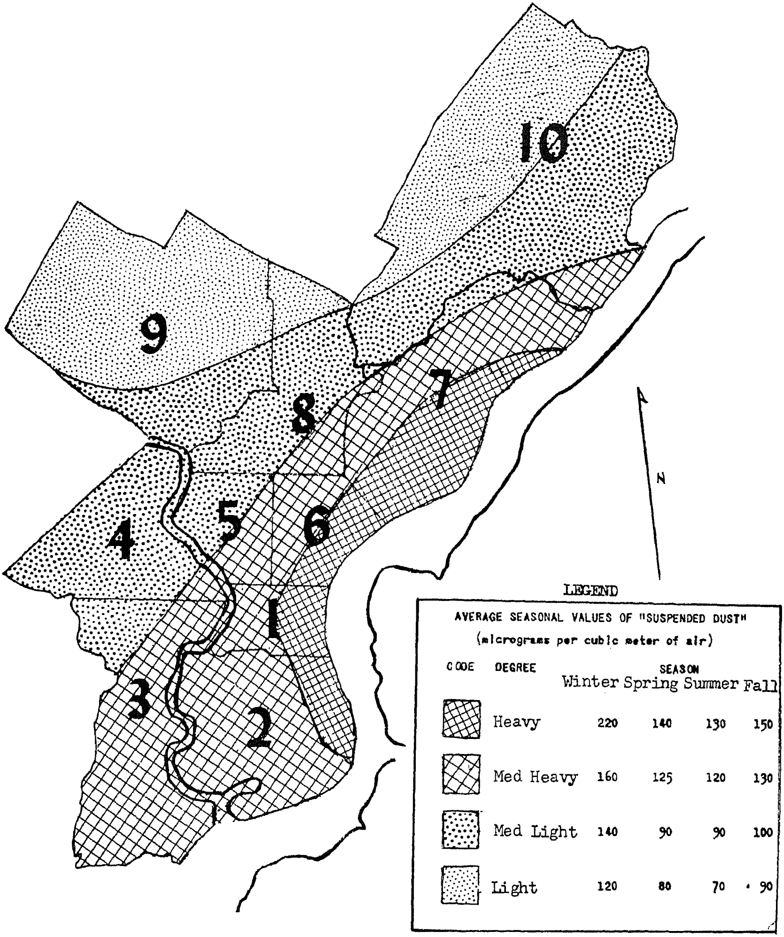


Figure 3
Estimated seasonal area intensities of oxides of sulfur, city of Philadelphia



LEGEND

AVERAGE SEASONAL VALUES OF "SUSPENDED DUST"
(micrograms per cubic meter of air)

CODE	DEGREE	Winter	Spring	Summer	Fall
	Heavy	220	140	130	150
	Med Heavy	160	125	120	130
	Med Light	140	90	90	100
	Light	120	80	70	90

Figure 4
Estimated seasonal area intensities of suspended dust, city of Philadelphia

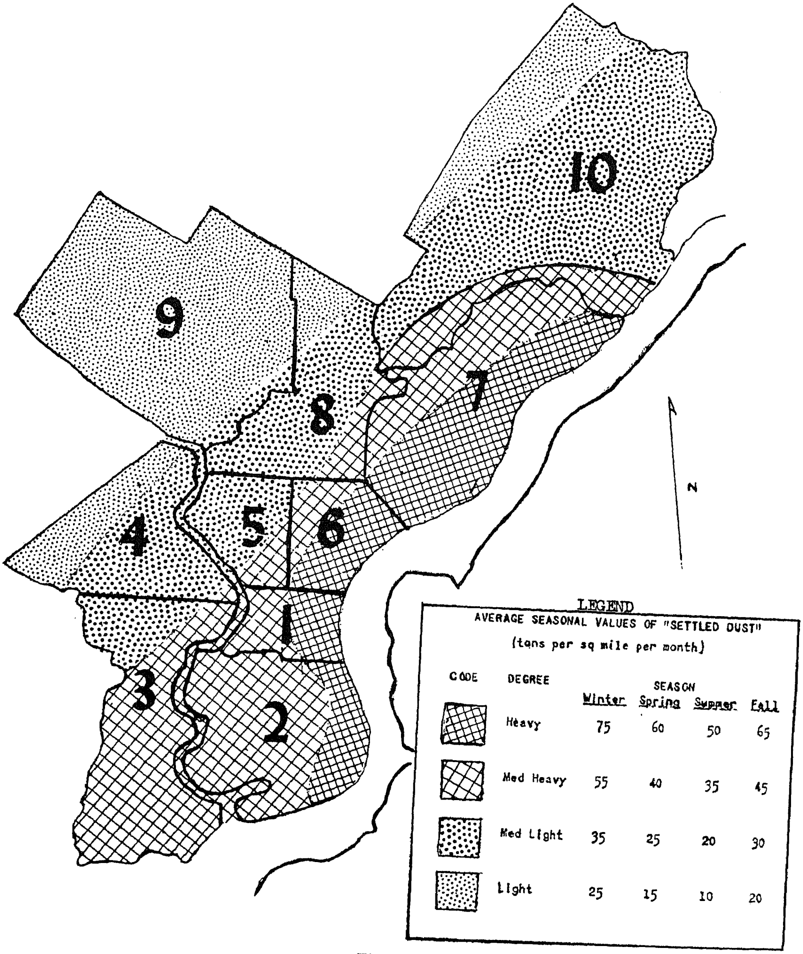


Figure 5
Estimated seasonal area intensities of settled dust, city of Philadelphia

This categorizing of pollution zones is also becoming a stimulus to research on the physiological effects which may result from different levels of exposure.

Our simple sampling is able to give us insight into the effect of certain community parameters on our problem. You will note in figure 6 the rather remarkable, but certainly expected, similarity between monthly usage of fuel and the existence of dirt and sulfur dioxide in our air. Such information clearly indicates that one of the main factors in the development of an air conservation program for Philadelphia must relate to the types of fuel being burned and the manner in which they are burned.

What else can we find out about some of these community barometers? The daily sampling of our air for sulfur dioxide indicates that its variation for days of the week is slight and random. Sampling for dust, however, indicates that our atmosphere is appreciably cleaner on Saturdays and Sundays. Is this due to less industrial activity on the weekend?

Observed air concentrations can be related to tonnage of emissions, not as skillfully, perhaps, as many theorists would like to see it done, but perhaps skillfully enough, with all its inaccuracies, to provide us with good clues on many problems. In this particular instance of cleaner weekends, we find that the drop in estimated tonnage of dust emissions from industry would account for only some 50 percent of the lowering of observed air concentrations. Traffic counts, however, were also found to be lower on weekends. When this drop was applied to our estimates of particulate matter resulting from the use of motor vehicles, we were able to find the missing link in our problem. The above, of course, is only one of many examples of how knowledge from monitoring can be utilized to better define the extent of contribution of numerous community factors to our air pollution problem.

The community's air quality is not made up only of usual levels of air pollution tempered by seasonal factors; it is also made up of emergency periods when the community's natural ventilation falls to a minimum and pollution levels rise to unexpected highs. Any program for air conservation must give consideration to such emergency periods.

The skills of the meteorologist are obviously needed in the proper definition of community ventilation. Many agencies have tended to throw up their hands and say that this is a skill which we cannot afford to employ. Such employment, however, need not be on a full-time or permanent basis. In Philadelphia, this service was supplied through the periodic use of a qualified consultant. The end result of his analysis indicates rather clearly that periods of minimum natural ventilation occur frequently enough to be of considerable importance.

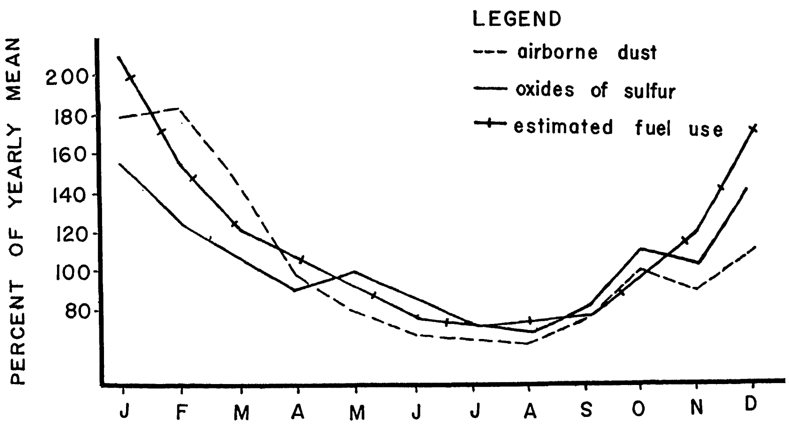


Figure 6

Monthly variations of air pollutants and estimated fuel use in Philadelphia

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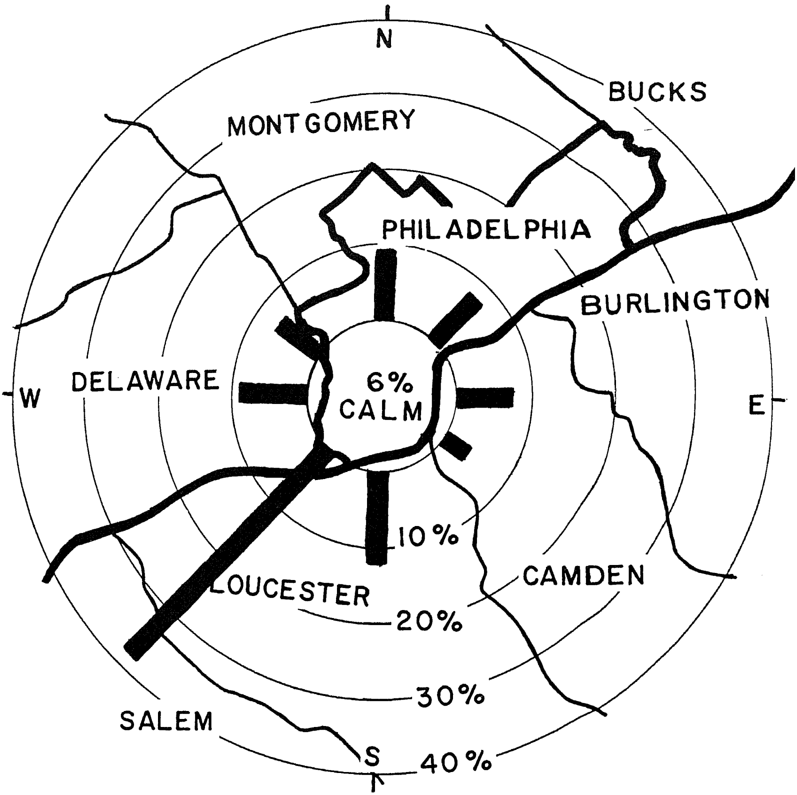

Figure 6a
Wind direction during periods of high pollution in Philadelphia

We can now demonstrate that the upswing in morning concentrations of sulfur dioxide and dust relates to the frequent occurrence of early morning inversions, and that the fumigations relate to when such inversions break up, just as strongly as the upswing in concentration relates to the periodic increase in pollution emissions.

More important than the above, however, has been some definition of the meteorological systems which lead to the longer emergency periods of minimal ventilation. The layman and the skilled professional often talk in terms of prevailing winds. Prevailing winds are not necessarily problem winds when we speak of air pollution. Prevailing winds in our area would generally be categorized as winds from the west through north. Our major pollution episodes, however, occur primarily with winds from the south through southwest. Such a correlation would have been impossible without air monitoring (fig. 6a). The importance of this information is rather obvious with respect to long-range programs on community planning, but it has another equally

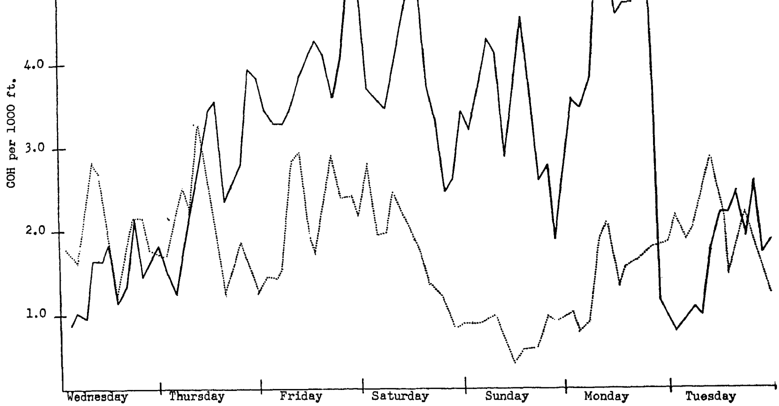

Figure 7

Effect of inversion type weather conditions on soiling index

or more important meaning. The association of our simple air monitoring data with meteorological parameters opens the possibility of forecasting such periods, and tying such forecasts to emergency procedures which can be instituted with certain types of pollution sources, where control otherwise might not be economically feasible.

To what extent will our pollution be concentrated during such emergency periods? An answer to this question is necessary, so that we may ultimately be sure that generally acceptable levels of air pollution which we may establish are not periodically concentrated into a lethal mixture. Again, simple devices can give us some idea of what takes place. In figure 7, you will note the obvious increase in dust during the Christmas weekend of 1959, when Philadelphia had a fog-smog episode. The AISI sampler used here is essentially automatic in operation, and remains on watch even in our absence. One can only speculate on just how high the indicated values might have gone if the period of occurrence had been one of maximum, rather than minimum, community activity.

We have photochemical smog, too. Periods of maximum pollution of this type require the use of more sophisticated instrumentation for definition. Such a period was indicated on August 31, 1962 (fig. 8) from test instruments placed in our community by the U.S. Public Health Service Continuous Air Monitoring Program. In this instance, eye irritation was reported from widely scattered parts of the community.

The object lesson of both of these periods is, once again, that the concept of air conservation is of immediate importance in our metropolitan area. It cannot await perfect knowledge. The lesson could not have been learned without the application of present monitoring know-how.

Can we theorize on how rapidly pollution levels will build up during emergency periods? We are fortunate in having some data for estimated tonnage of emissions of various pollutants in Philadelphia (fig. 9). Our consulting meteorologist provided us with a very simple formula predicting the rapidity of such a buildup for sulfur dioxide and the terminal concentrations which it might probably reach, based on our estimates of emission tonnages.

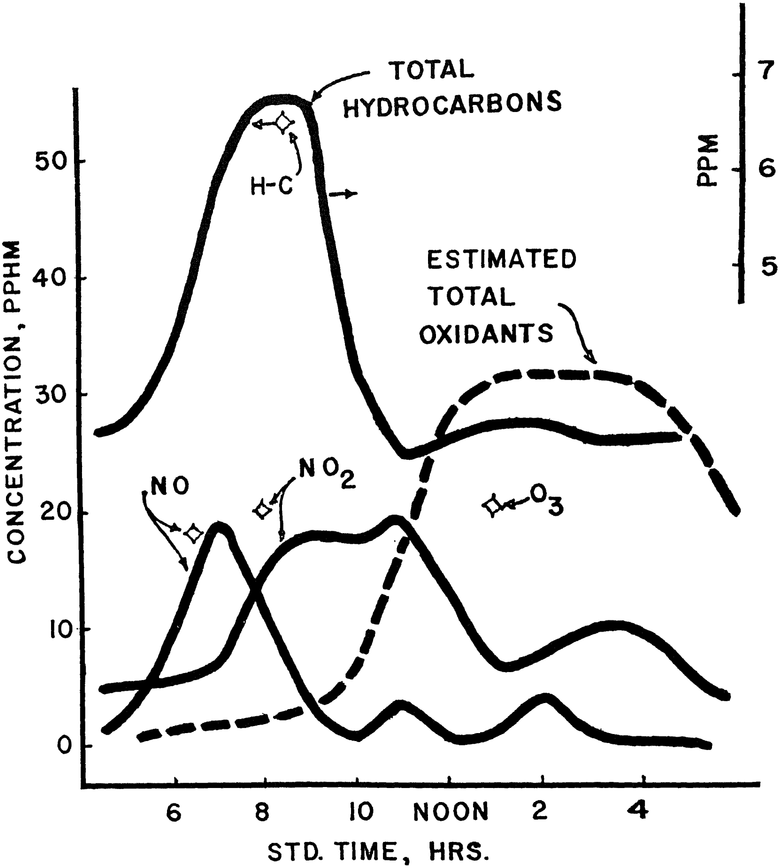

Figure 8

Pollutant levels during eye-irritating smog in Philadelphia and average Los Angeles peak values

Once again, we come to the question of whether or not we need perfect knowledge. I am sure that many meteorologists will question the exactness of the theory involved; however, it does have the advantage of providing us with some idea of the limits which will be imposed on the situation. You will note in figure 10 the similar slopes of sulfur dioxide buildup with these theoretical curves, in two recent cases. The knowledge is not perfect, but it gives us a good working idea of what we may anticipate.

Where does all this lead? You can't sell clean air on hot air! We must have information on air quality to sell long-range planning programs to the community and to the elected official. Where such information is available—and much can be obtained through relatively simple monitoring

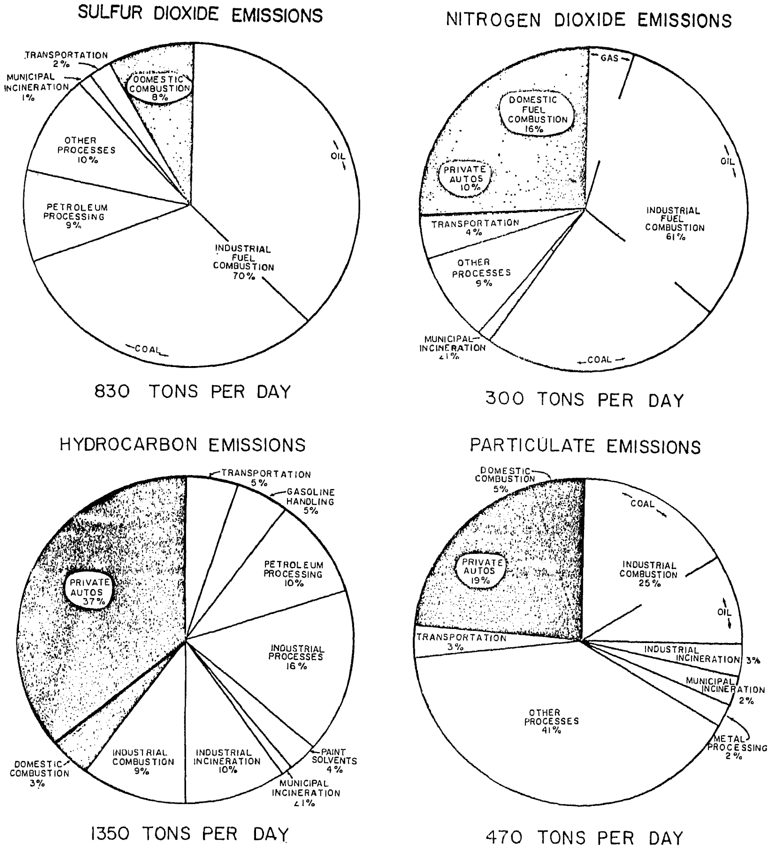

Figure 9

Sources of air pollution emissions in Philadelphia

methods—we open the door to air conservation programs. Reasonable estimates are being made, every day, of the tonnage of pollutants being emitted into the air of communities, throughout the country. These estimates are not perfect, but their precision is sufficient to provide us with a point of beginning. Furthermore, estimates of tonnages of pollutants can be projected into future years. With this knowledge and the knowledge of some of the factors making up our air quality, we are prepared to take the first step and say what we want our air to be like in the years 1970 and 1980, and for the first time, we may be prepared to properly apportion the tonnage reduction needed to take this first step for air conservation. The more information on our air quality we obtain from existing monitoring methods, the more we will stimulate research aimed at both a better definition of each

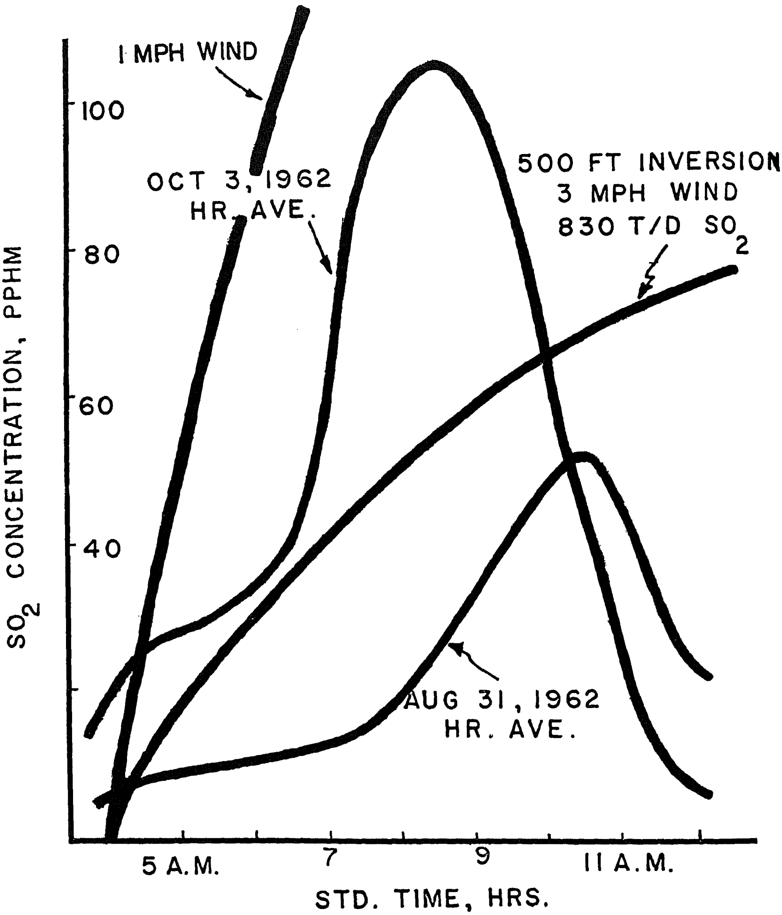

Figure 10

Measured episodes of high sulfur dioxide vs. predicted increase in Philadelphia

contaminant and a better definition of its possible physiological responses.

Perfect knowledge will not spring as a full-grown plant from the ground. Its seed must be nurtured through imperfect knowledge, utilized as best it can be, tested, re-examined, thought over, fought over, and improved with time. The process must begin some place. We must not complicate ourselves and our problem by lacking the courage and the initiative to utilize present knowledge. Let's face it. Today, lack of budgetary support of air pollution control in the United States, at all levels of government, indicates clearly that we know more about how to sample the air than we know about how to obtain the necessary community support. But, through the application of the one skill, we may obtain the other.

This was Philadelphia on October 3, 1962, as shown in figure 10. Sulfur dioxide concentrations remained at approximately 1 part per million for a period of 3 hours. The haze was obvious. We will have many more October 3ds if we don't use our present knowledge and skills to provide us with an air conservation program, in addition to those programs aimed at nuisance firefighting.

Prepared Discussion: APPLYING MEASUREMENTS AND MONITORING KNOW-HOW

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When we speak of the use of air sampling know-how, the assumption is made that some form of consensus exists on the use of air sampling data. I am not at all sure that any sort of real consensus exists. Too often, when air sampling programs are undertaken, sampling data are used for score-cards that appear in annual reports, in summaries, and in comparisons. Admittedly, the public information function of air sampling is important, but the important role that air sampling plays in control technology must be recognized also.

What is this role? The answer to this question lies in two further questions:

1. What is the objective of the sampling?
2. What resources are needed to achieve this objective?

By way of illustration, I should like to refer briefly to two surveys similar in nature, carried out locally in widely separated areas of New York State. From both areas, citizen complaints have been received alleging air pollution. In one instance, a point source was involved, this one being the largest apparent emitter in an essentially rural area. In the other instance, a fair-sized municipality also in a rural area was involved, and there were a number of large apparent emitters. The complaints in both instances were concerned with the deposition of particulates.

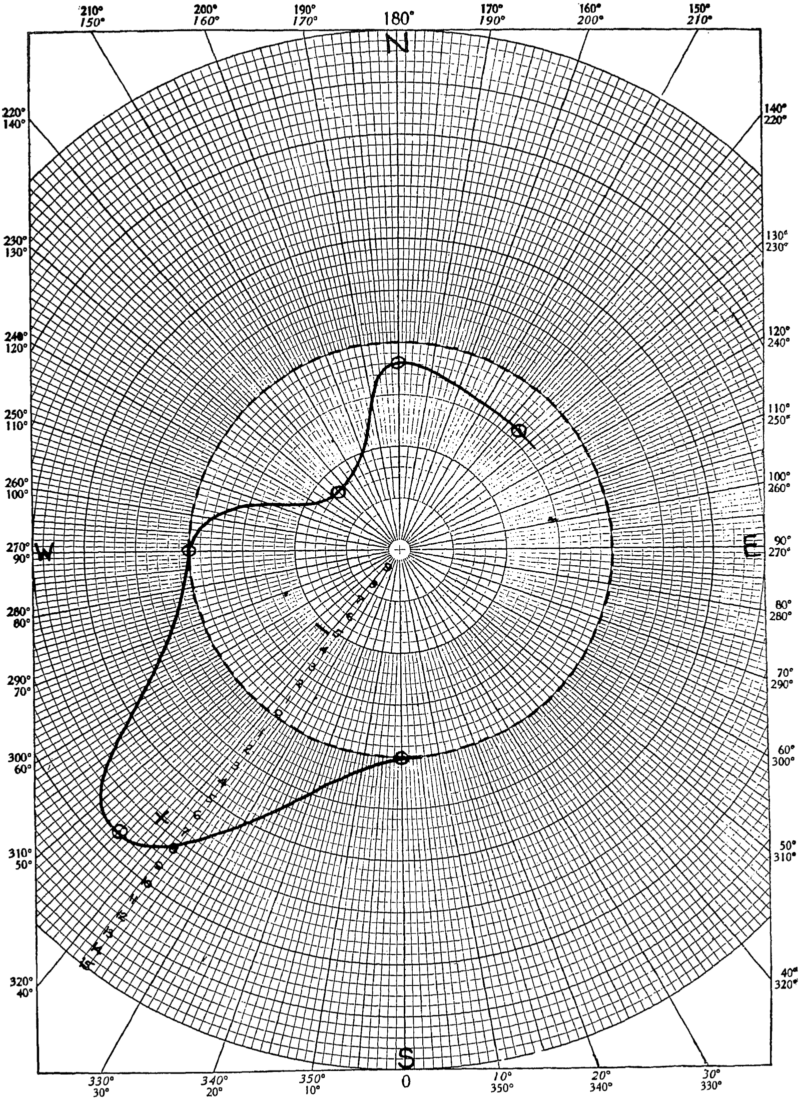
A network of American Iron & Steel Institute (AISI) tape samplers, and wind recording equipment was used in the investigation of each of these problems. The sites that were selected were representative, based on an objective evaluation of the locations, topography, meteorology, and of course, the availability of power and space for operating the equipment.

The resulting data were then handled in an interesting and fruitful manner. Since the complaint was based on sporadic occurrences of particle deposition, it was judged that the problem for the bulk of the time was within acceptable limits; that is, no complaints resulted. On this basis, the lowest and highest deciles of the AISI tape sampler data and the associated wind direction data were selected as being descriptive of the problem. By the mathematical manipulation of assigning a negative value to each occurrence in the lowest decile and a positive value to each occurrence in the highest decile, and algebraically adding the number of occurrences from each of the eight major wind directions, it was possible to obtain a plot on polar-coordinate graph paper which gives an indication of the relative pollutional burden and direction (fig. 1).

The conclusions derived from these studies were:

1. Area or point sources could be located directionally, and the net effect of discharges could be evaluated to some extent.
2. It was established that the effect a source has on a receptor can be put to a test, using analytical tools such as sampling and meteorological observation.

In regard to the second conclusion, it was shown that with a specific wind regime, objectionable localized conditions could result. Using the adjec-



180°
210° 150°
200° 160°
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170° 190°
160° 200°
150° 210°
220° 140°
140° 220°
230° 130°
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240° 120°
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250° 110°
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260° 100°
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270° 90°
90° 270°
280° 80°
80° 280°
290° 70°
70° 290°
300° 60°
60° 300°
310° 50°
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320° 40°
40° 320°
330° 30°
340° 20°
350° 10°
0
10° 350°
20° 340°
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N
S
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E

Figure 1

tival rating system of Monroe,[1] it could be concluded that there was no continuous area problem. In one investigation in which 5,139 spots were evaluated, 93.7 percent had a rating of light particulate levels, and an additional 5.8 percent had a rating of moderate particulate levels. However, the 0.5 percent balance did result in conditions that were objectionable. Generally, the same results were obtained in the second investigation.

In both surveys, a two-stage objective was met. First, the nature and extent of the problem was determined. Second, information was developed which would lead to eventual solution of the problems.

In the case of the point source problem, it was demonstrated to management that the operation should be evaluated, and as a result, corrective measures were undertaken which reduced the particulate emissions. With the municipality, on the other hand, it was demonstrated that a number of localized problems did exist, and that a more detailed study was needed. As a consequence, a comprehensive air pollution survey is planned for the early part of 1963 in this area.

The two studies that have been described indicate the specialized skills which may be required and therefore answer, in large part, the question regarding resources. In both of these undertakings, the following personnel classifications were involved:

1. Engineers.
2. Laboratory personnel.
3. Meteorologists.
4. Statisticians.
5. Equipment technicians.

By no means is it meant that these are the only skills needed. As studies more complex in nature are undertaken, the spectrum of required skills is broadened to include, among others, those of physicians, sociologists, plant pathologists, and botanists. The need for additional skills depends upon the objective of the study.

Other types of sampling with similar objectives will utilize similar sample collection and analytical techniques, similar personnel, and similar supporting instrumentation. In all cases, the statement of objective must be made, formally or informally, and then the resources needed to achieve this objective must be committed and utilized. Though there may be some debate about the equipment or the procedures, this is a minor problem.

Air sampling is an attempt to identify and/or to quantify what is present in the atmosphere. It is of unquestioned value in providing information essential to the definition of the problem. Properly carried out and evaluated, even with the equipment and techniques available today, it is a necessary first step in achieving the solutions we all seek.

[1] "State-Wide Air Pollution Survey—Smoke Index," by William A. Monroe, New Jersey State Department of Health, 1958.

DISCUSSION

Amos Turk. About 10 years ago, when systematic atmospheric analysis was on the threshold of coming of age, perhaps 1 year before the start of the National Air Sampling Network, the predominant question was, in Dr. Rossano's words, "What pollutants should be measured?" Early attempts at approaching complete analysis of atmospheres, such as Martin Shepherd's liquid air trapping and subsequent mass spectrometric examination of gases and vapors, revealed an analytically appalling multiplicity of components. Again in Dr. Rossano's words, "the list of candidates is almost inexhaustible." What has happened during these 10 years? As Dr. Rossano has so aptly described, we've witnessed a powerful extension in time and space of the sampling and analysis of a relatively small number of components, selected because of their importance as pollutants and, perhaps to some degree, also because of amenability to analysis. Progress in more intensive analysis of individual samples of polluted atmospheres has been less spectacular than the extensive network sampling progress described by Dr. Rossano.

Not all research groups concerned with multicomponent atmospheres have taken this approach. One industrial laboratory, for example, has completed the identification of 300 components in cigarette smoke. Likewise, agricultural and food chemists have identified from food sources many individual components. The object of such work, of course, is to continue the search for the recognition of components which, either singly or in synergism with others, may be significant to the problem at hand. I'm aware that the availability of time and effort for atmospheric analysis is not unlimited.

My question, Dr. Rossano, is this: Has the magnitude of our effort in the extensive survey of the relatively few atmospheric components to some degree displaced the development of effort in the intensive analysis of individual atmospheric samples and, if so, would a partial shift in this ratio of efforts give more balance to our program of measurements of air pollutants?

Rossano. You have raised a profound and pertinent question. As I mentioned in my paper, almost anything that is foreign to the atmosphere can become a pollutant. Consequently, there are perhaps thousands of chemical compounds, as well as innumerable physical and biological agents which are potential contaminants. Obviously, it normally would be impractical to sample for and analyze each and every one of these constituents.

In air pollution surveys there usually are certain objectives, or at least guidelines, which in a sense determine which substances to look for. If air pollution effects or manifestations are observed, one looks for the contaminant or contaminants which are suspected or known to produce such effects. For instance, if blackening of lead-based paint happens to be the air pollution problem in question, the obvious suspect is hydrogen sulfide. The use of such guidelines helps to narrow the field down from a tremendous number of possible agents to a manageable few. Naturally there are certain inherent risks in this approach, since the causative substance is not necessarily the one which is most apparent. However, something should be said in defense of the considerable attention being given to certain specific pollutants such as sulfur oxides and nitrogen oxides, for example. There are clear indications that these substances are of hygienic and economic importance, and consequently, deserve serious attention.

There are also certain considerations which may be the determining factors in deciding what should be analyzed. Among the important ones are cost and time. A mass spectrometer analysis of a gross air sample would provide rather extensive information on composition. However, the cost of such analyses, as well as the time and technical skill required are frequently far beyond what most organizations can provide.

Lastly, there is the question of feasibility. There are cases when one desires to analyze for a specific compound or class, but the lack of relatively simple equipment and techniques makes such analyses unfeasible.

There is considerable room for additional research and development on new methods and instruments for obtaining analyses in depth. It would be most desirable to be able to put a representative air sample into an automated device which would analyze the sample and produce a complete chart or record showing the types and relative amounts of a wide variety of pertinent pollutants. Although progress is being made in this direction, I do not feel that the effort being put into speeding up the development of such sophisticated equipment is commensurate with the need. Until these advanced systems are available, time, cost, and feasibility considerations require that routine air sampling and analysis be restricted to selected sub-

network of any kind, those setting it up
cide what questions they want their sampling program to answer. Although it is often desirable to sample for a specific substance which has a direct effect, such as fluoride in Florida, the substances sampled are usually general indices of pollution. Because of differences between communities, I feel that each should choose its own indices, basing its choice upon its own needs and the questions its authorities want answered. The availability of instrumentation often imposes severe limitations, however.

Although we are interested in the health effects of air pollution, there is unfortunately no single substance whose concentration serves as a good index to health effects. For example, knowledge of NO_2, oxidant, and SO_2 concentrations does not really tell us what the air is doing "biologically." I should like to put in a plug even stronger than the previous ones for the use of biological indicators. A few years back, Alexander Goetz spoke of encouraging the inclusion of biological indicators in these sampling networks. He said: "You know, I've always felt that an *E. coli* is much closer to a human being than is a solution of potassium iodide."

As a footnote, I should like to encourage an interest in the presence of heterocyclic nitrogen compounds in the air. They are emitted from several types of sources and are quite active biologically.

K. K. Huffstutler. Mr. Linsky, recently I have gotten the impression that you are not enforcing regulation 2 on sulfur dioxide in the Bay Area? Is this true?

Linsky. We are enforcing our regulation on sulfur dioxide and it operates at two levels. Any plant that emits a higher concentration than 2,000 parts per million not only must maintain a ground-level monitoring system but also must stay within certain limited concentration and time effects. We have had some plant upsets and we also have some plants which are not in conformance with regulation 2. They have been under compliance schedules while installing initial corrections, for example, a full sulfur recovery plant associated with a refinery operation. In one case, there have been upsets at a sulfur recovery plant which have resulted in high concentrations of sulfur dioxide beyond those specified in the regulation. Under the upset cific legal enforcement action.

Huffstutler. How do you cope with a situation in which the sulfur dioxide is carried over the property line, thus circumventing your regulation, which sets limits at ground level at the property line?

Linsky. The concentration and duration limits are set for ground level at and beyond the property line. Some of the company monitoring stations are placed near the boundary, some are placed on neighboring property. In addition, we spot-check with our own mobile sulfur dioxide measuring equipment to be certain that we pick up the high concentration sites ourselves. We have had some companies relocate their stations as a direct result of our mobile sampling checks, in cases where stations were not properly sited, so that we do meet this problem head on.

Genaro G. Costantino. In reference to Mr. Raymond Smith's paper, I am impressed by the accomplishments brought about under his able leadership. His is not an agency blessed with a surplus of funds and with automatic public and official support. So he has had to make the most of what he has. Like Ray, I have always thought that the desire for precise scientific knowledge before taking action is more often than not an alibi for inaction. Some of the methods he uses and proposes in his paper would appall the purist. But the proof of his theories is demonstrated by the available evaluating data. To me this is a good indication of what can be done, without perfect or complete knowledge, but with a surplus of good commonsense and logic, in planning for the inevitable increase in air pollution which we must expect in the future.

L. B. Morgan. The board of directors of the Bay Area Air Pollution Control District, of San Francisco, Calif., has taken a position on each of the subjects that are before us at this conference. So far as this panel (E) is concerned, we have two major points.

No. 1. The Federal Government should undertake the development, publication, and circulation of air quality and source emission standards and development of equipment to be used as nonenforceable program guides by States, counties, and other jurisdictions.

The Federal Government should assist, financially, in the practical development of standardized procedures and hardware for various types of air monitoring and stack sampling. These procedures should range from the simplest methods and hardware that could be used by small industrial operators and small communities, to the most sophisticated methods and hardware for complex situations and highly specialized technical groups.

The Federal Government, in developing these standardized procedures, should utilize the current developments of instruments and telemetering that are used for long-range submarines and space cabin atmospheres, as well as in chemical warfare and ordnance storage.

No. 2. The owner of an air pollution source should, at his own expense, do such measurements and observations as he needs to assure his conformance to community air pollution standards—legal or voluntary.

Government agencies, at each level that has a regulatory responsibility, should do such measurements, and other observations as are needed, to assure conformance with legal requirements. They should also do measurements and observations to provide a foundation for changes in legal requirements.

Public, private, and semipublic study and research groups should do such measurements and observations as are needed to establish correlations of pollutants with effects, to provide a basis for both voluntary and legal air quality standards.

Supplementary Statement Submitted for the Record

By Genaro G. Costantino, *Chief, Division of Air Pollution and Mechanical Equipment and Installations, City of Providence, R.I.*

There are three areas in which the Federal Government, through its proper agencies, can aid local air pollution control authorities.

One of these would be to furnish emergency kits of prepared reagents for use in sampling for gaseous pollutants during periods of inversion and air stagnation such as occurred last week on the east coast. Because of the lack of necessary laboratory facilities, we in Providence could make no determination of the amounts of the gaseous pollutants which were present during the stagnation period.

Another is to furnish or make available air quality sampling equipment to all communities or agencies which are desirous of maintaining a daily sampling program, but which lack the finances for the necessary instrumentation.

A third and most important area is a matter of the Federal Government setting the pace in "Clearing the Air," by specifying adequate air pollution control equipment in all structures where Federal funds fully or partly finance the cost of construction. An example would be housing projects or Federal buildings, where incinerators are usually specified. Local authorities do not have jurisdiction, but the proper Federal agency should specify minimum standards of performance from equipment likely to create air pollution. Performance based on the standards specified should be the basis of acceptance of the equipment.

CONCLUDING REMARKS

MOYER D. THOMAS
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At the beginning of these concluding remarks I should like to paraphrase Dr. Hilst's paraphrase, "Cast thy wastes into the atmosphere and they will immediately pass beyond thy control." We will then have to accept any effects, good or bad, expected or unexpected, wherever or whenever they appear. Some defensive measures have been discussed in the literature. For example, farmers might spray their plants with lime sprays at frequent intervals to avoid fluoride damage; galvanized metal might be painted with a resistant paint to avoid atmospheric corrosion due to sulfur dioxide; and people might wear respirators against smog. In all probability the nuisance would then exceed the pollution.

There appears to be unanimous agreement in this group that monitoring programs need to be set up to determine the concentrations and exposure periods of the different pollutants in various locations. These will supply the basic quantitative information on which the evaluation of the air pollution problems and the decision to institute remedial measures at the source must be based, also the information for judging the effectiveness of the remedial measures and the necessity for enforcement measures. As Dr. Hilst suggested, the evaluation of monitoring data must be based on a knowledge of the sources of the pollutants and their effects on plants, animals, and property. Dr. Rossano also emphasized this concept of the three-phase nature of the air pollution control problem: knowledge of (1) the sources, (2) the transportation and dispersion in the atmosphere, and (3) the receptors. He cited many examples of air pollution monitoring.

The diluting capacity of the atmosphere varies with the meteorology but has definite limitations which, if exceeded, may cause annoyance to the senses; economic damage to plants, animals, and property; and suspected injury to health. The objective of an air pollution program is to prevent pollutant levels at which these adverse effects can occur.

A few years ago, the only recognized air pollutants of practical importance were sulfur dioxide and coal smoke, with arsenic and lead from smelting operations as minor pollutants. Today, Dr. Rossano lists the following as major pollutants in addition to radioactive wastes: (1) corrosive gases and aerosols in general; (2) sulfur dioxide; (3) carbon monoxide; (4) hydrogen sulfide; (5) lead; (6) fluorides; particulates as (7) dusts and fumes, and as (8) dark smoke; (9) odors; photochemical smog, including (10) oxides of nitrogen, (11) hydrocarbons, and (12) ozone and other oxidants such as PAN (peroxyacetyl nitrate). There are also organic compounds such as aldehydes and acids and organic aerosols with or without sulfuric acid aerosol. And probably there are many other pollutants not now recognized as important.

"Each air monitoring program must be geared to the needs and resources of the individual community."

Much emphasis has been placed on the importance of responsibility at the local level for the monitoring programs. Where a significant local problem exists, the individual emitter can profitably monitor his own emissions. Many industries have made substantial expenditures for remedial equipment when the extent of their air pollution contribution was established by themselves or others. But, of course, it is the responsibility of the community to monitor the pollutants which are of multiple, nonspecific, or "public" origin. And, as Dr. Hendrickson pointed out, this monitoring should be carried out by the lowest level of government capable of doing the job. However, as suggested by both Dr. Hendrickson and Mr. Linsky, the States and the Federal Government must assume respon-

sibility (1) for much of the research and delevopment of new methods and instruments; (2) for coordination and for computer handling and publication of the local data; and (3) for the "development, publication, and circulation of air quality and source emission standards."

The expense involved in continuous monitoring has been mentioned by several speakers and it appears to be taken for granted that hand monitoring with simple equipment on a grab-sample or intermittent basis is a satisfactory procedure involving much less expense than continuous monitoring. This position needs careful examination. While it is true that initial cost of automatic recording equipment is greater than that of hand-operated analyzers, when the cost of operation is considered, the overall cost will generally be smaller and the number of analyses much larger with the automatic equipment. For example, 16 sulfur dioxide autometers were operated for years in the Salt Lake Valley on a round-the-clock basis. One man spent 2 days a week servicing the instruments and he traveled about 100 miles on these days to do so. Another man did most of the data reading and summarizing by half-hour periods on monthly data sheets. A complete record was thus available at all points of interest in the area to meet any possible need for information. A large number of chemists would have been required to do this job without automatic analyzers if the same amount of data were collected, which of course would never be done.

It should be noted that, even though a large part of the automatic recordings are zero or too small to be significant, they are still useful as indicating the absence of pollution. In our experience, average pollution levels occur about 5 to 10 percent of the time and maximum levels only about 1 to 2 percent of the time. The probability is therefore great that the high peaks, which are of greatest interest, will be missed except by continuous recording. They have a distressing habit of not occurring during regular working hours. The peak of the 1952 London smog was present during the weekend, which was covered by a 48-hour sampling period with no short-time analyses to indicate maxima. And Mr. Smith was able to evaluate a serious smog-fog episode in Philadelphia during the Christmas weekend of 1959 because he had a continuously recording tape filter analyzer in operation when the routine analysts were not working.

After many years of experience, I have no doubt that automatic analyzers are highly desirable, if not essential, in most air pollution monitoring programs. For this purpose, additional research on instrumentation is obviously needed to simplify and make less expensive the analyzers now available and to develop new instruments for pollutants not now subject to instrumental analysis. The new data-logging and computer techniques will expedite the handling of the data.

Even for some short-term survey jobs, automatic analyzers may have important advantages. Anyone who has "chased smoke" with a portable analyzer knows how frustrating and unsatisfactory this process can be. Whereas one or two continuous instruments, properly located, might be able to make a better short-term survey with much less expenditure of manpower. Experience has shown that continuous sampling at a well-selected spot usually determines satisfactorily the maximum, minimum, and average concentrations of a large area.

It is highly important that the monitoring program should include recording of wind direction and velocity and, if possible, temperature gradients to define atmospheric stability. Without these meteorological data, it is not possible to evaluate the dispersive processes in the atmosphere or to predict pollution levels. The highest concentrations are usually associated with low wind velocities and strong inversions. The interesting study described by Mr. Maneri in New York State and the wind velocity and temperature inversion effects in Philadelphia illustrate the importance of meteorological data for an understanding of the air pollution syndrome.

Fortunately, the occurrences of disasters due to air pollution are rare. There has been only one "Donora," and only one "Meuse Valley," that we know of. Poza Rica is not in the same category. However, there have been a number of lethal smogs in London in addition to the major 1952 disaster. The severe smog plaguing that metropolis at this moment emphasizes the fact that acute problems are still with us. There are a great many susceptible people in the large population of London and it is not surprising that some should be fatally affected by lesser pollution than occurred in 1952. The "alert" program in Los Angeles is designed to prevent such an occurrence there.

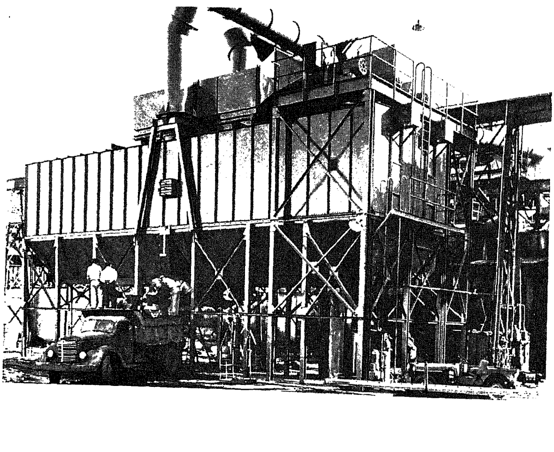
One unknown feature of the London smog is the role played by sulfuric acid aerosol, produced by oxidation of sulfur dioxide. It is well known that the acid is much more irritating to breathe than sulfur dioxide. A report has just been received of

a 3-hour concentration of 2 p.p.m. sulfur dioxide and 0.6 mg/M^3 of sulfuric acid aerosol (equivalent to 0.15 p.p.m. H_2SO_4/M^3). It is hoped that complete analytical data will be available for these two pollutants in the present episode. Without such data, one can only speculate on the contributions of the acid and sulfur dioxide to the lethal effects and irritations of the smog. It would appear advisable to include sulfuric acid aerosol in the list of substances monitored, wherever sufficient sulfur dioxide is present to form a significant amount of acid under pollution conditions which at this time are very poorly understood.

I conclude with Dr. Rossano: "In man's never-ending quest for a better and safer environment, constant vigilance to protect our most vital air resources is both a necessity and a responsibility."

Panel F

APPLYING OUR CONTROL EQUIPMENT AND METEOROLOGICAL CONTROL KNOW-HOW



Applying Present Know-How to Air Pollution Control

Chairman: Melvin W. First
Co-Chairman: William R. Chalker
Reporter: Harry Hovey

Participants

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INTRODUCTORY REMARKS

MELVIN W. FIRST
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Having isolated and identified air pollutants, and established their harmful effects upon humans, animals, vegetation, and property, the final step is to do something about it.

There are three general methods that are used, individually or in combination, to control emissions of pollutants to the atmosphere. These are:

(1) *Process control or modification.*

A first step in seeking a solution to an air pollution problem is to consider process changes and raw material substitutions which will reduce or entirely eliminate the offending substance or substances. In some cases the use of materials less offensive from the air pollution standpoint, but more costly, results in a lesser economic burden on the process than the application of alternative air pollution control measures. A familiar example of the benefits that may be derived from raw material substitutions, is the substantial improvement which has taken place in many urban atmospheres as a direct result of the replacement of coal by the smokeless fuels, oil and gas, for domestic and commercial heating.

(2) *Atmospheric dispersion.*

A second method for controlling industrial emissions to the atmosphere is to provide a means for complete dilution and dispersion of the effluent gas streams before they have an opportunity to reach ground level. This is generally accomplished by discharging offensive materials to the atmosphere through tall stacks. Often, dispersion is aided by heating the gases (to impart greater buoyancy) or by discharging them upward at velocities in excess of 45 miles per hour. Tall stacks have proved most effective for dispersing air pollutants in flat or gently rolling country, and in areas with reasonably stable atmospheric conditions. Smelter stacks that rise to 600 feet, and the current practice, in our country and in the British Isles, of building powerplant stacks in excess of 300 feet, are indications of the importance placed on this method of air pollution control.

(3) *Air and gas cleaning.*

The removal of offensive substances from air and gas streams prior to release to the atmosphere is a third method of air pollution control. A wide selection of gas treating devices is available for this purpose, and their selection and proper application are engineering problems of growing importance. The extent to which this is true may be judged by the fact that, not infrequently, the cost of air and gas cleaning devices exceeds the cost of the productive machines they serve.

Although these three procedures are simple in concept, their execution frequently requires solutions for problems of great technical complexity. Whereas many believe that we now possess sufficient engineering and scientific know-how to control, by one means or another, all known sources of air pollution, it is only fair to point out that not all control procedures can be justified economically on the basis of our present knowledge of the harmfulness of certain air pollutants.

Does this mean that poisonous atmospheres should, or must, be tolerated on economic grounds? Certainly not. It is clear, nevertheless, that many of our air quality standards are based on esthetic considerations rather than on demonstrated harmfulness. Does this mean that esthetic standards for regulating air purity have no validity? Again,

the answer must be "no." A sizable segment of our affluent western population believes quite passionately that esthetic standards are valid and that we can, indeed, afford clean air; that it is one of the good things of life. Anyone who doubts this should attend a New England town meeting in a suburban bedroom community when a proposal is on the evening's agenda which would amend the zoning laws so as to permit the entry of a new industry.

Each of us is likely to experience some measure of ambivalent feelings when we consider our own dual role as consumers of air, on the one hand, and as creators of air pollution, on the other. This means that our desire for ever better air quality must be tempered by a recognition that the search for economically acceptable means to bring this about has not yet been fully realized. On the hopeful side, it seems reasonable to believe that the same high level of technology which will send men to the moon and back will furnish the technical means for maintaining satisfactory air quality. Our panel session this afternoon is concerned specifically with how best to do it and how large the bill will be.

THE STATUS OF METEOROLOGICAL KNOWLEDGE AS A FACTOR IN AIR POLLUTION CONTROL*

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The first national Technical Conference on Air Pollution held in this city in 1950 included eight papers on meteorology; the present session contains one. On this basis, one might conclude that recent progress in meteorology has been virtually nonexistent or that the importance of meteorological factors has been diminishing. Neither could be further from the truth, as the number and quality of papers relating to air pollution meteorology in recent scientific and technical sessions will attest. It is particularly appropriate to review the status of meteorological know-how at this time, because of the many situations in which the ultimate capability of the atmosphere to absorb pollution is in question. In connection with highly toxic materials on the one hand and the megalopolis on the other, estimates of the "atmospheric sewer capacity" are becoming increasingly necessary to industrial and municipal planning.

It is informative, however, to review the proceedings of the 1950 session to gain perspective as to the changes which have occurred. Of the eight papers, one was of a summary nature, the second presented a limited amount of new field dispersion data, the third summarized the micrometeorology of a hilly region, and the remainder contained little more than qualitative descriptions of installations, techniques, and proposed research.

For the author of the summary paper in 1962, the problem is not how to obtain information to fill out the paper, but rather how to mention most of the important work in the allotted time. The progress, and I am convinced that there has been significant progress, has been based on the interest and support of many agencies, both governmental and private. First, and chronologically, in this country there has been the Chemical Warfare Service, whose investigation of air pollution predates that of others by many years, although security measures have limited the general distribution of its results. The first strong impetus toward meteorological research in air pollution came from the Atomic Energy Commission, which early recognized the need for meteorological evaluation of its problems, and has proceeded to support extensive basic research at its national laboratories, the universities, and other contractors. The military agencies, particularly the U.S. Air Force and the U.S. Army Signal Corps, have recognized the importance of basic understanding of low-level meteorology, and both maintain active unclassified programs. Recently, the U.S. Public Health Service has lent strong support to work in air pollution, both at its own facilities and through its contractors. Many other agencies, such as the National Science Foundation and the Tennessee Valley Authority, to name two, also have contributed substantially.

Missing from the list above is the U.S. Weather Bureau, obviously not because of lack of participation, but rather because its activities have contributed to virtually all other phases of research in this field.

Finally, the universities, private industrial groups, and municipal agencies must also be mentioned. The work in the Los Angeles area is outstanding and, although it is almost impossible to separate the individual contributors effectively, one could cite a lengthy list of valuable research projects.

*Research carried out under the auspices of the U.S. Atomic Energy Commission.

The purpose of this presentation is to outline the present status in regard to the availability of meteorological knowledge, and to review its utilization in the air pollution problems confronting us. In this the author has made use of the excellent material prepared by Barad (*2*) for the Interdisciplinary Conference on Atmospheric Pollution, and by Wanta (*3*) and Strom (*4*) for their respective chapters in "Air Pollution."

1. THE INDIVIDUAL POLLUTANT SOURCE

It is now generally conceded (*5*) that the meteorologist can predict the dispersion of gases or true aerosols with reasonable precision, in simple terrain, over modest distances. Numerous examples of successful meteorological applications are documented in the literature, involving subjects ranging from site selection, planning, and evaluation (*6*), to meteorological control and forecasting (*7*). Other equally good examples exist, but they have not been released for public relations reasons. While much remains to be learned concerning the theory of atmospheric turbulence and the related diffusion and deposition, the practical application is reasonably sound.

One might note a parallel between the modern physicist who is plagued by difficulties in achieving a theory capable of unifying the multiplicity of particles and emanations revealed by recent research, but still utilizes his imperfect knowledge to construct reactors and other equipment of considerable engineering sophistication.

Similarly, the meteorologist now has sufficient empirical information concerning the single source in flat terrain to enable him to predict with accuracy the time-mean concentration downwind. Many projects have contributed to the basis of such estimates. Probably the most elaborate and complete series of studies of a ground-level source was conducted at O'Neill, Nebr. in 1956 under the auspices of the Geophysics Research Directorate (*8*) with the participation of many scientific groups. A similar series of tests at Hanford is now providing data at considerable distance from a low-level source, during temperature inversion conditions (*9*). The latter is a joint effort of the Atomic Energy Commission and the Geophysics Research Directorate. Field data which have helped to establish reliable values of effluent concentrations from elevated sources have come from a number of projects in this country, notably those at Hanford (*10*), the National Reactor Testing Station (*11*), Brookhaven (*12*), and the Tennessee Valley Authority (*13*). The British studies at Harwell (*14*) have also been helpful.

An important factor in achieving useful predictions of ground-level concentrations has been an improvement in knowledge of the height to which hot stack gases will rise. For this, particular credit must be given to the Tennessee Valley Authority (*15*) and to Argonne National Laboratory (*16*).

The preoccupation with field data should not be taken as evidence of lack of theoretical progress. While [it is fair to say] no spectacular advances in theory have been made, considerable amplification of our understanding can be claimed. For example, the recent book by Pasquill (*17*), and papers by Gifford (*18*), Barad and Haugen (*19*), and others, have clarified and detailed many aspects of earlier work. However, the field data are necessary to evaluate any of the theoretical models, whether the well-known work of Sutton (*20*) or one of the more sophisticated treatments is used.

Computer techniques have advanced more rapidly than either theoretical knowledge or accumulation of data. At Brookhaven, for example, a re-evaluation of reactor concentration distributions was recently accomplished in a few minutes, whereas the initial study consumed 1 year of effort in 1949. Instrumentation and the techniques for using them have also been improved. It has been shown, for example, by Davidson and Halitsky (*21*), that for the simple short-range problem, knowledge of the standard deviation of wind fluctuations is a suitable means of estimating certain diffusion parameters, and at the present time, instrumentation is becoming available (*22*) to permit computation of this type of information on a routine basis.

Thus, at present the common problem of the individual pollutant gas or aerosol source in simple terrain can be treated satisfactorily from the engineering standpoint. Accuracy of the order of ±50 percent in concentration predictions can be expected under the most favorable circumstances (*23*). As one departs from ideal circumstances, however, the accuracy of estimates falls off.

Terrain and Vegetation

Without much question, the most important complexity is associated with variable terrain and ground cover. One cannot predict either concentration levels, or trajectories, in complicated

terrain with the same accuracy as is possible over an open plain. There is no reason to believe, however, that these problems are so formidable that they cannot be solved. Holland's early summary of the micrometeorology of the Oak Ridge area (*24*) has more recently been augmented by other investigations of the effects of terrain, such as those by Wilkins (*25*) and Davidson (*26*). The last suggests that ridge and valley flow follows reasonable patterns, even though it may often be necessary to undertake tracer testing in order to define all details. Studies such as those at Shippingport (*6*) can easily serve as models for future investigations.

The possible influence of vegetation on concentration levels has received little attention, although it seems apparent that either physical or chemical effects may be present. Recently, Singer (*27*) has pointed out that short-term concentration fluctuations may be reduced substantially by dense vegetation.

In connection with terrain and to some extent with other complicating factors, one should review the work in atmospheric modeling. At the time of the first Technical Conference in 1950, many felt that this area of research had great promise, and that conceivably many major studies could be conducted in wind tunnels rather than in the natural atmosphere. This promise has been fulfilled so far only in regard to local flow patterns in the close vicinity of structures and prominent terrain obstacles, as evidenced by the work of Sherlock and Lesher (*28*) and Strom (*4*). It is still possible that the use of wind tunnels may be profitably extended to other types of problems (*29*), but reliable data have yet to be presented.

Discussion of tracer techniques is also appropriate, since they are often needed in evaluating flow in complex terrain. For trajectory studies requiring visual observation, oil fog is still an excellent medium. However, several methods of higher quantitative accuracy have been developed. The use of uranine dye, first reported by Robinson (*30*), has been outstandingly successful. The detection of zinc cadmium sulfide or zinc sulfide particles, as used at Stanford University (*31*), has been widely tested and is now a well-established technique. Even the routine industrial pollutant, sulfur dioxide, has proved valuable (*8*). Two relatively new tracers also deserve mention. The U.S. Weather Bureau has perfected the no-lift balloon, now known as the Tetroon (*32*), and Brookhaven Laboratory has developed a tracer method utilizing radioactive copper spheres in a variety of size ranges (*33*).

Extended Distances

A second concern to the meteorologist is the matter of extended distances. Even in open terrain, one cannot define precisely how the diffusion patterns may be modified at 10, 20, or 30 miles from the source. Most thinking in regard to this is somewhat speculative, although data are gradually becoming available to clarify the situation. It is important to note that this is a most vital consideration in estimating the maximum reasonable size of an individual pollutant emission. As plant size increases, concentrations at great distances may become the controlling factor, regardless of stack design and output parameters. While insufficient to define many aspects of the problem, studies at longer range have been reported by Elliott (*34*) and also by Crozier (*35*) and Leonard (*36*).

Variations of Concentration With Time

Many projects in air pollution have been limited by the sampling techniques available, and most field diffusion studies have provided only integrated measurements over fixed time intervals, with the result that our knowledge of time-mean concentrations is far more complete than that of short-term variations. Gifford's paper (*18*) gives an excellent background for understanding these problems, and those by Hilst (*37*) and Singer (*27*) provide field data showing the relations between peak concentrations and longer-term values.

Deposition

There is still another aspect of the single-source problem which as yet has not been treated adequately, and this concerns the transfer of particulates from the atmosphere to the ground and vegetation. Both because the field research is difficult and because a prior understanding of diffusion is required, the deposition problem has not received adequate attention. The information which is available would lead us to believe that particles less than 10μ are probably removed from the atmosphere more rapidly than one might suspect from laboratory data. Current research into these problems is of three basic types: estimates of deposition by inference, from the depletion of airborne material (*38, 39*); direct field measurements of deposition, of the type being conducted at Brook-

haven (*33*); and study of the physical processes (*40*). Important work with naturally occurring particulates (pollen) is also being conducted at the University of Michigan (*41*) and at Brookhaven (*42*). It is not unreasonable to anticipate that work of this kind will assist in the evaluation of the several theoretical approaches to the problem, such as those of Chamberlain (*43*) and Vanderhoven (*44*).

Adequacy of Data

The background data required for evaluation of single-source problems vary in both quality and quantity. Frequently ignored, perhaps because they are obviously complete, are the standard climatological data available in the National Weather Records Center in Asheville, N.C. From this source, a wealth of information on temperature, relative humidity, solar radiation, and wind can be readily obtained.

Certain specific types of data useful in air pollution evaluations, such as the low-level lapse rate data, wind profiles, and wind fluctuation records, remain in short supply, although the data are more nearly adequate than they were 10 years ago. An important contribution is the study of the frequency of inversions recently completed for the entire United States by the U.S. Weather Bureau (*45*).

A word of caution is in order regarding the utilization of existing data to evaluate new problems. It is most important to be certain that the data are representative, and they may fail to be, for many reasons. Smith (*46*) has noted that certain wind data may be representative at distances of 100 miles or more, while other observations may not reflect conditions one mile away. Also, instrumentation may not always have been maintained adequately for the more stringent demands of air pollution applications.

Utilization

It is interesting to note that both government and industry have made extensive use of the technical capabilities which have become available for single-source evaluations. In many instances, the capabilities had to become available to permit evaluation of some of the more difficult dispersion problems. However, it is certainly true that most sources likely to produce serious air pollution are now considered from the point of view of environmental factors, from the time the site comes under consideration, through the design of the plant and the establishment of operating procedures. It is regrettable that many of the results of these applications do not reach publication, and it is certainly appropriate to remind this audience that many valuable pieces of data are residing in private files. Some could be published without jeopardizing the organization's public relations position.

2. *MULTIPLE POLLUTANT SOURCES*

Most of the foregoing can be reiterated when one considers a complex of sources varying in height, horizontal position, and emission characteristics. The typical oil refinery, for instance, includes many sources, each of which may contribute to the general pollution problem. Study of such a plant 10 years ago would have been a virtually impossible task, because of the manpower required to make the analysis. However, this is no longer so; computer techniques make it feasible to subject such a plant to as thorough an air pollution evaluation as is required. It is, for example, possible to study and prepare composite pollution estimates for 10 to 15 individual sources with approximately the same expenditure of effort required for a single source a decade ago.

There is one area in which the knowledge of the meteorologist needs amplification. This is the common problem of a series of stacks, so close together that the effluent from them partially blends into what appears to be a single plume. One recognizes that this problem cannot be treated with complete accuracy by assuming that the concentrations from the various sources may be added together graphically. Neither can one assume that the individual emissions merge completely enough to be considered as a single source, except at great distances. At present, the only information published which has any direct bearing on the problem is that provided by the Tennessee Valley Authority (*13*). While these data are useful, they are limited to the parameters typical of steam powerplants.

The application of meteorology to the complex plant study, as opposed to the individual source, has proceeded at a considerably slower rate. Only recently, in fact, have thorough studies of entire installations become commonplace; previously they were not undertaken unless actual pollution problems had necessitated the effort. The technical capability, however, is adequate for this, and the reduction in both the time and the cost required

should result in more complete evaluations in the future.

3. *THE LARGE AREA POLLUTANT SOURCE*

The subject of municipal air pollution has received far more attention from the meteorologists within the past 2 or 3 years than at any prior time. With the single exception of Los Angeles, most cities in the United States have never been studied in any great detail as far as micrometeorology is concerned, but this type of work is progressing. Two sets of discussions, one held in Cincinnati (*47*) and the other in Michigan (*5*), have focused attention on a number of special problems relating to cities, and a number of interesting conclusions about our current knowledge have come from them.

In the first place, it is apparent that the diffusion and micrometeorology associated with cities is different from that found in open terrain. The city (presumably, this is true of all large cities) serves as a significant heat source in itself, with the result that it presents a "heat island" in the atmosphere (*48*). Over such areas, the surface temperature inversions frequently found in the country are not observed. Furthermore, the city itself presents a series of complex roughness elements, probably unlike the trees, hills, and grasses of open country. These roughness elements are large enough to impede the windflow and affect its turbulence in the areas in which the pollution is of greatest interest. In the cities, both the sources and the receptors are often in the roughness elements, rather than towering above them.

Added to the above complexities is the complication introduced by a multiplicity of sources varying in height, time, and horizontal location. It would seem that the solution of the municipal problem must be 20 years behind that of the simple individual source. However, this is not the opinion of a number of meteorologists today, particularly those who have had direct contact with municipal studies at first hand. For example, at the Michigan conference it was the consensus that many of the municipal problems might prove to be simpler than anticipated, since fine details tend to be obscured by the fact that there are so many sources and turbulence-generating elements. If this simplification is genuine, major changes in the meteorological factors are the ones which must be correlated with municipal problems. Studies such as those by the Travelers Weather Research Center (*49*), the U.S. Weather Bureau (in [...] nection with its forecasts of major pollution [...] cidents (*50*)), and others, such as those at L[...] ville (*51*) and Nashville (*52*), support the [...] that a simple approach may be effective.

One important difficulty in evaluating muni[...] air pollution is the fact that little of the at[...] pheric sampling in cities has been planned [...] due consideration of the micrometeorology. [...] is a statement of fact rather than a criticism. [...] until recently neither sampling nor meteoro[...] techniques have been up to the task. Th[...] constitute a partial explanation for the ap[...] lack of strong correlation between meteoro[...] variables and municipal air pollution levels. [...] easy to see, for example, that samplers serv[...] references to general levels within a mun[...] area might best be located outside the city at [...] distance. Their utilization as standards [...] then depend upon the wind direction.

New approaches such as that originally su[...] by Frenkiel (*53*), in which one would evalu[...] city with the aid of computer programs, [...] be undertaken. This has been done at N[...] (*52*), and several other approaches to this p[...] have been suggested at the Cincinnati conf[...] (*54, 55*) and elsewhere (*56*). These deser[...] ful study.

Furthermore, even if it is found necessary [...] on complex mathematics, there is no long[...] reason to avoid the procedure. Computer [...] tication now permits the development of [...] tration patterns from a wide variety of [...] individual sources. The task is still a lar[...] but only by approaching it systematically [...] determine how much simplification in pr[...] can be tolerated.

4. *SUMMARY AND CONCLUSIO[...]*

It is felt that the meteorological profes[...] made significant progress in the solution [...] pollution problems within the past 10 to 1[...] Empirical data and techniques of applicati[...] progressed particularly rapidly, and the me[...] gist can now offer sound engineering advice [...] in site selection, site planning, facilities desi[...] establishment of operational procedures, a[...] evaluation of existing problems.

Concentrations from single gaseous or [...] sources in simple terrain can be estimated [...] accurately, although greater uncertainty ap[...]

as the terrain becomes more complex, and factors such as deposition, unusual time periods, or great distances are involved. Multiple sources offer some additional difficulties but, as the number of sources becomes very large, as in a city, the meteorologist anticipates certain simplifications owing to the obscuration of fine detail.

The available techniques have been utilized widely in the solution of single-source problems, but very few thorough municipal applications have been attempted. While this is understandable as an historical fact, the meteorologist sees no valid reason for continuation of this situation. The required knowledge, instrumentation, and methods are adequate for the task, and even our limited experience suggests that many improvements will be found in the future.

It seems certain that carefully planned, interdisciplinary attacks on the large-scale air pollution problems are the only means of elevating these efforts to a scientific, rewarding level. To accomplish this effectively, all disciplines, including meteorology, must participate actively from the earliest planning to the final evaluation of such programs; such a situation is rare enough to be called unique today.

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Prepared Discussion: THE STATUS OF METEOROLOGICAL KNOWLEDGE AS A FACTOR IN AIR POLLUTION CONTROL

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The preceding discussion by Mr. M. E. Smith has provided a comprehensive enumeration of many types of air pollution problems in which the weather plays a role. He has indicated, accurately, I believe, that there have been significant improvements in the status of meteorological knowledge which can be applied to air pollution control.

I should like to expand somewhat further on this. It appears to me that this improvement has come primarily through advances in understanding on a very broad front in many areas, rather than through a major change in knowledge in any one scientific field. In other words, the search for knowledge has led to a better understanding and a better description of the whole field of air pollution, including weather effects. These advances indicate the magnitude of the problem, and have shown us just how intimately the problem of air pollution is tied to the problem of meteorology.

It is axiomatic that the weather is complex. Today's traveler may, in a few hours, see beneath his aircraft bewildering cloud patterns, layers of two or more storm centers, clear areas, fogs, smoke palls near the cities, and high-altitude haze layers, as he travels from coast to coast. When the hundreds or thousands of different types of pollutants emitted from thousands or millions of sources are added to this complicated system, the complexity of the problem is indeed staggering.

However, order and understanding have been introduced by considering certain common factors which seem to dominate air pollution levels. These factors vary with time of day and with season; they may be different in different portions of the country, but invariably some aspect of the weather is found to be important.

One of the most important relationships between weather and air pollution is a peculiarly contradictory one. When weather and air pollution are considered on an hourly or daily basis, it is the weather which shows the wide variations and changes. On the other hand, in our highly industrialized and highly mobile economy, when we compare average conditions over years or decades, it is the weather patterns which are stable and the character and amount of pollution which show the widest variation. Sutton (1961) puts it as follows: "Although the physical properties of the atmosphere undergo large short-period variations, averages taken over periods which are certainly not long, in the geophysical sense, are remarkably stable." Fortunately, it is here that meteorological knowledge is well grounded in an extensive body of weather records, extending over many decades.

Turning now to my colleague's order of discussion, we consider first the individual pollutant source. As Mr. Smith indicated, this type of problem, outside the urban area, is relatively well in hand. A particular type of localized source is, however, emerging as a special problem requiring solution. This is the very large powerplant (with an output of hundreds or thousands of electrical kilowatts). It appears that such plants can emit enough heat to significantly modify their local environment, particularly the height to which the stack emissions will rise. As a consequence of their size

tions and measurements of pollution concentrations may be required several tens of miles from the source. Our knowledge of the behavior of pollutants released in this fashion over such distances is indeed meager, as has been indicated. However, techniques exist to examine the problem. The crucial question of height of emission can be studied from visible plumes by photographic techniques developed by Culkowski (1961), a method both economical and practical. The direction of the effluent plume over tens of miles can be accurately traced by the use of special balloons and radar (Angell, 1962; Pack, 1962). Thus, while the state of knowledge actually in hand is insufficient, we know in general what is needed, and we have developed hardware that can obtain the measurements.

Another aspect of this review of our current status that has been mentioned is the advantage provided by high-speed computers. It is agreed that these machines have expanded our capabilities enormously. This is nowhere more evident than in meteorology. The National Meteorological Center of the Weather Bureau now prepares a very large portion of its weather analyses and predictions by computer (Fawcett, 1962). However, the mere capability of high-speed calculation does not guarantee solutions to problems. Rather, we are now permitted to experiment with the relations of complex meteorological variables, and with the equally complex and voluminous air pollution source estimates. These experiments now can be done in a matter of minutes rather than months; there is promise that in the future, when appropriate measurements are obtained, calculations of pollution levels within an urban area can be done in sufficient time to provide air pollution agencies with continuously updated pictures of current and predicted air pollution levels. Before this can happen, however, much rigorous thinking and extensive field experimentation must go into the design of computer models and into the designation of the number, frequency, and kind of observations required for realistic results.

At the beginning of this discussion, it was mentioned that there has been a general advance of understanding in many of the scientific areas concerned with air pollution. There are also, very naturally, problems where less progress has been made. One of these is the variation of concentration with time. As Mr. Smith has indicated, some

relating average- and short-term concentration pollutants, primarily for the single discrete sourc Much less is known of the influence of weather c short-term variations from multiple sources, f example, on automobiles or on residential heatir in urban areas. Concomitantly, there is a lac of knowledge of the relative importance of tl effects of these short-period high concentrations c man, plants, or materials, as compared with low levels maintained for longer periods of time. I addition, until recently, with the activation of tl Continuous Air Monitoring Program (CAMP there has been a notable lack of any large quanti of short-period concentration measurements. Thu we have a situation in which we cannot be sui whether or not it will be necessary to investigai further the connection between weather and shor period concentration variations. Since there is n dearth of problems that already require study, would be useful to have a determination from th specialists in air pollution effects on the necessit for embarking on a more intensive study of th very difficult problem.

Turning now to another area in which ou knowledge is still less than desirable, we must con sider the way in which the air cleanses itself c pollutants. It is obvious that this cleansing actio must be quite efficient, or the billions of tons c pollutants entering the air each year throughou the centuries would have prevented any life as w know it. Studies of this phenomenon (which her will include the precipitation cleansing mechanisr as well as dry deposition) have generally been a opposite ends of the spectrum. At the large end c the scale, we have a rather good idea, from re search done on the removal of radioactivity, of th global removal rates in the lower 30,000 to 50,00 feet of the atmosphere. This "residence time" about a month. At the other end of the scale, fo distances of a mile or less, we know (Simpson, 1961 Islitzer, 1962) that the deposition can remove, i a short time, from 10 to 90 percent of airborne pol lutants emitted from a ground source. What w do not know quantitatively is the action of deposi tion on the city scale and, particularly, the physica mechanisms of how this action occurs. If we wer to learn more of the physics of this process, it migh be possible to accelerate the removal rate and im prove, locally at least, the cleansing process. Thi ability may become increasingly important as w

approach emission rates which might saturate the dilution capacity of the air.

On the other hand, it is possible to strike a more positive note on the availability and the understanding of existing meteorological data for air pollution evaluation and control. Mr. Smith has properly pointed out that, for specific locations, data taken at other points cannot always be accepted literally. However, much can be accomplished by skilled interpretation and extrapolation. The work of Frederick (1962) has shown how existing airport wind records can be related to wind flow across a city, to mention only one example. It is obvious that joint correlations of short-period records at a specific site with those of permanent long-duration stations can extend the value of the special observations. This aspect of data and data utilization can be increasingly useful as the number of specific site studies for industrial plants, particularly nuclear installations, becomes greater in all sections of the country. Information sources for many such studies include the Atomic Energy Commission's *Nuclear Science Abstracts,* the American Meteorological Society's *Meteorological and Geoastrophysical Abstracts,* especially the section on "Climate of Particular Places." Direct inquiry to the Atomic Energy Commission, the Public Health Service, or the Weather Bureau may often elicit a surprising amount of useful data. The Weather Bureau has recognized the increasing interest in the application of standard weather observations to air pollution problems, and the Office of Climatology issues a variety of summarized data which contain a wealth of information, particularly on wind. Routinely available, for many locations, is the monthly "Local Climatological Data and Supplement." Summarized data for 10 years for about 200 cities are being published in the series "Climatography of the United States, No. 82," and more elaborate analyses will be available in "Climatography of the United States, Series 40—Climatic Guides." Again, however, one must join with Mr. Smith and reiterate that the uncritical use of such data can be misleading, while on the other hand, careful interpretation can mean significant savings of time and money in air pollution studies, and can lead to better air pollution measurements and control, hence, to cleaner air.

Mr. Smith has discussed the large area, or urban, pollution source. I should like to broaden this particular topic and discuss urban air pollution and weather in the framework of regional and national air pollution problems. It has been pointed out that man no longer adapts to his environment, but rather, changes his environment to suit his present capabilities. Most of the time, this change is planned and controlled. However, in urban areas, man has brought about changes that he has not planned and only now is beginning to try to control. The following table (Landsberg, 1961) shows changes in the urban environment, many of which are brought about by air pollution.

Climatic changes produced by cities

Element	*Comparison with rural environs*
Contaminants:	
Dust particles	10 times more.
Sulfur dioxide	5 times more.
Carbon monoxide	25 times more.
Radiation:	
Total on horizontal surface	15 to 20 percent less.
Ultraviolet:	
Winter	30 percent less.
Summer	5 percent less.
Cloudiness:	
Clouds	5 to 10 percent more.
Fog:	
Winter	100 percent more.
Summer	30 percent more.
Precipitation:	
Amounts	5 to 10 percent more.
Days with <0.2 inch	10 percent more.
Temperature:	
Annual mean	1 to 1.5° F. more.
Winter minimum	2 to 3° F. more.
Relative humidity:	
Annual mean	6 percent less.
Winter	2 percent less.
Summer	8 percent less.

As more and more of our land area and what is certainly the bulk of our population become urbanized, we are significantly altering, as the above table shows, the environment of a majority of our citizens. While the changes in temperature, humidity, and precipitation may not matter, the increase in contaminants and cloudiness and the decrease in solar radiation would seem to be definitely in the wrong direction.

Of course, the air pollution which brings about these changes may present very different problems in the different cities. Sources may be widely different in character and in the circumstances (height, frequency, season, etc.) of their significant emissions. Just as importantly, in some locations the city may have grown so that large segments of the population are downwind during pollution

episodes, although normally the pollutants would be carried by the winds in more favorable directions. Other urban areas may have developed in such a manner that the pollutant usually moves across the city, but the accompanying weather conditions favor rapid dilution. Thus, each community poses a different set of questions to the air pollution study team, including the meteorologist, or to control officials. Fortunately, however, the weather data sources previously mentioned, sometimes augmented by well designed meteorological measurements, can now provide definite guidelines for optimum air quality sampling, zoning changes, control actions, and design data for air cleaning equipment.

However, there are at least two factors operating to create a common problem in air pollution in most urban areas. The first is the growing volume and presence of air pollution due primarily to automobile exhaust products, and the second is the gradual merging of individual city areas into gigantic urban complexes. The eastern seaboard of the United States from Boston, Mass., to Richmond, Va., is often pointed out as one such area where a single enormous "strip" city, or megalopolis, is developing. However, other areas, for example, Chicago to Cleveland, Los Angeles to San Diego, and possibly the Ohio River Valley, are not far behind. In such areas, we have millions of sources, almost uniformly distributed, which raise real problems of "Who is polluting whom?" and "What is clean air?" A pioneering study by Holzworth (1959) attempted to determine the characteristics of "clean" air entering the west coast. Presumably, the "clean" air reaching New York City with a southwest wind is quite different. Visually, this is evident to the jet aircraft traveler. The increasing density of the visibility-reducing material becomes strikingly evident during a flight from the west coast to the eastern seaboard. (It must be stated, however, that not all of this reduction can now unequivocally be ascribed to manmade pollution, but a significant fraction must be the result of man's activities.)

This, then, is the potential problem. It has occupied a growing amount of attention and weather research by the Weather Bureau during the past several years. We have begun to summarize air pollution weather factors in regional patterns. The early work of Korshover (1960) has been followed by studies of Hosler (1961) and Holzworth (1962a, 1962b).

General regional patterns of the frequency and extent of slow atmospheric dilution are emerging. Prediction of periods of slow dilution over large areas east of the Rockies has been a standard Weather Bureau forecast service since the fall of 1960. At the present time, pollutant emissions seem to be at a rate which requires, fortunately, relatively rare and long-lasting stagnant weather patterns before air pollution rises to high values over large areas. However, in the last 2 years, 27 forecasts have been issued for conditions favorable for high pollution potential. We believe that we understand, and can predict reasonably well, weather situations of the "episode" type.

On the other hand, knowledge of the day-to-day problem of what sources contribute significantly to the average levels of air pollution in a megalopolis is far from satisfactory. It now appears that, for most cities, a very large fraction of the air pollution is "homemade," essentially from local sources. This may not be true in the future, and the time to evaluate the problem and devise solutions is now. A crude initial study of the problem, for a few sources, was done manually by Pack and Hosler (1958). This study took several weeks of hand calculation and is completely infeasible for the urban air pollution problem. It is here that the capability of high-speed computers will permit research that would otherwise be impossible.

Studies are underway in the Weather Bureau to extend the capability of numerical weather techniques to predict wind movement near the surface. At the same time, a beginning is being made in the use of modern tracer techniques to determine quantitatively how pollution is transported into and out of an urban complex. Combining the results of the field experiments with computer-evaluated meteorological theory will provide fresh insight into ways to control air pollution on a regional and national scale.

To summarize our status, the meteorologist is now an integral member of the interdisciplinary attack on air pollution. Working answers are available for many specific problems created by discrete sources of air pollution, and many data and much knowledge of the weather effects on average pollution levels within urban areas are at hand. We are on less sure grounds in dealing with pollution sources in complex terrain or weather conditions, and knowledge is lacking on the relation between weather and short-period concentrations of pollutants. (As previously men-

tioned, there is also a gap in our knowledge of the effect of these transitory high values.)

Fortunately, these areas are recognized, and research is underway to extend our knowledge of these special fields. Finally, some of the air pollution problems which may face us in the future have been outlined, and considerable effort is being expended to find the answers, including the effects of weather, before megalopolis-induced air pollution is upon us.

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THE STATUS OF ENGINEERING KNOWLEDGE FOR THE CONTROL OF AIR POLLUTION

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No longer is there any need to continue to saturate the literature with warmed-over comments on the air pollution disasters which have occurred in several parts of the world. Surely there now must be agreement that most, if not all, of the urbanized centers of the world have air pollution problems. Surely there must now be agreement that these air pollution problems will continue to grow. Surely there must now be agreement that these air pollution problems must be solved.

No longer is there any need to continue the debate on whether or not open burning dumps should be allowed.

No longer is there any doubt that open burning of scrapped automobiles, rubber tires, insulated wire, and battery cases should be prohibited.

No longer is it in order to cast doubt on the desirability of having pollution-free, cut-and-cover sanitary landfills rather than smoky, dusty, municipal incinerators.

No longer should industry be allowed to beg delay in controlling gray iron cupolas, open hearth furnaces, electric furnaces, aluminum, brass, bronze, and other nonferrous furnaces, on unsupported claims that much-needed research and investigation are still required (*1–4*).

No longer should the petroleum refining industry claim exemption from air pollution regulations on the ground that it is not feasible to control refinery operations (*3, 5, 6*).

No longer is it necessary to condone dense clouds of smoke from boilers, incinerators (*7, 8*), and other combustion equipment.

No longer is there any excuse for operators of food-processing equipment, coffee roasters, asphalt paving plants (*9*), asphalt roofing manufacturer concrete batch plants, galvanizing kettles (*10*) fertilizer and rendering plants, fish canneries, glas furnaces, mineral operations, or paint and varnis cookers (*11*) to continue emitting air contaminant without regard for their neighbors (*1, 2, 3*).

No longer is it necessary for the chemical in dustry or the tire and rubber industry to inforr the public of its existence by releasing into th atmosphere odors which defy description.

No longer must vast sums of money be spent i determining whether or not the automobile is major source of air pollution.

After 14 years of the most vigorous contr program ever witnessed, and after the expenditur of $29 million, one of the largest metropolita county governments in the United States hε demonstrated that industrial operations and cor munity activities can be performed without inte ruption and within stringent air pollution limit

How long will it take for the government offici and the industry representative to admit the e istence of these air pollution problems and t earnestly promulgate the much-needed legislatior How long will it take them to admit the existenc of the solutions and to diligently install the muc needed control equipment?

How long must the public continue to suffer an endure the costs, annoyances, and possible healt hazards from polluted air?

How long must the public continue to swallo excuses that there are no solutions available f preventing pollution from government-own sources?

How long will industry's empty threats of relocation be acceptable as an excuse for a do-nothing policy of air pollution control?

How long must the public await the modification of the internal combustion engine to rid our atmosphere of hydrocarbons, oxides of nitrogen, and carbon monoxide?

The effects of polluted atmospheres are evident in every urban area. Most urbanized areas throughout the world have really only begun to experience these effects. But, they have begun, and no longer can the finger be pointed at Los Angeles with the feeling that "there, but for the grace of the weather, go we."

It is possible for an urban community to have the foresight, backbone, and wisdom to enact the necessary rules and regulations and to stand behind their rigorous enforcement. Air pollution problems can be solved, using sound technical and engineering approaches, coupled with enlightened administrative and legislative action.

The past decade has seen tremendous accomplishments in the control of air pollution in the face of the continuing expansion of the great metropolitan areas of our nation. As an example, since 1948, the population of Los Angeles County has grown from 3.9 million to 6.5 million; the number of vehicles has increased from 1.5 million to 3.4 million; the number of industries has increased from 9,800 to 16,000. The increase continues day after day without any halt in sight. It is expected that by 1970 the population of Los Angeles County will reach 8 million persons. At that time there will be 4.7 million vehicles choking its streets and freeways and 19,000 industries competing in almost every aspect of commerce. Based on the experiences of the last 14 years, stringent control measures have not been a deterrent to either new industry locating in Los Angeles County or to the expansion of existing industry.

In spite of this growth pattern, the engineering and enforcement functions of the District have resulted in preventing 4,500 tons of air contaminants from stationary sources from entering the Los Angeles atmosphere each day. (See table 1.)

Of this improvement, control measures affecting petroleum refineries have been responsible for removing some 1,700 tons. The prohibition on burning high-sulfur fuel oils resulted in eliminating some 775 tons. The ban on single-chamber incinerators and open burning resulted in preventing another 400 tons from entering the atmosphere. The program on control of dusts and fumes from mineral and metallurgical industries accounted for another 230 tons.

Of the 4,500 tons not now entering the Los Angeles atmosphere each day, 1,150 tons are hydrocarbons, 1,160 tons are sulfur dioxide, 1,635 tons are carbon monoxide, 380 tons are aerosols, and 170 tons are oxides of nitrogen.

In addition to the expenditures by the district for its research, engineering, and enforcement programs, industry has expended during this same period $103 million for the installation of some 10,000 new control equipment units. During a 14-year period, the district has approved applications for authorities to construct, and permits to operate, basic production equipment valued at some $700 million. There is no doubt that the cost of the basic equipment includes untold millions required to insure that the operation of that equipment will comply with the exacting standards of the district's rules and regulations. Moreover, although there are no descriptive figures available, vast sums of money also are unquestionably spent each year for the operation and maintenance of both basic and control equipment. Records indicate that the cost of air pollution control equipment, on the average, is approximately 25 percent of the cost of the basic production equipment.

With two exceptions, the use of organic solvents and the use of fuel oil, it is believed that stationary sources are controlled in Los Angeles County to the limit of present technology. The emissions of air contaminants from all uncontrolled stationary sources are considered to be at minimum levels, reducible only by expenditures of a magnitude that does not presently appear warranted.

Table 2 shows the accomplishments of each category of industry from 1948 to 1962. For example, six major and nine small independent refineries, in total, emit 87 tons of hydrocarbons and other organic gases. When this figure is divided by an estimated 400,000 individual points of emission in these 15 refineries, it is most apparent that not much more remains to be done.

These minimum levels, however, will present a problem in future years unless there is effective control of the last remaining major source of air pollution in Los Angeles County—the gasoline-powered vehicle, or if continued growth allows the fractional emissions remaining to aggregate to significant

TABLE 1.—*Tons of contaminants prevented from entering Los Angeles atmosphere daily from stationary sources, January 1962*

Emission source category	Hydrocarbons and other organic gases	Sulfur dioxide	Oxides of nitrogen	Carbon monoxide	Aerosols	Odors
Incineration and refuse burning	125	20	20	170	75	x
Fuel oil burning [1] (powerplants, refineries, and others)	7	575	150	...	40	...
Petroleum refining:						
Catalytic cracking	25	...	...	1, 465	5	...
Storage	350	...	...	...	...	x
Separators and sewers	105	...	...	...	...	x
Blowdown and relief valves	125	...	...	...	...	x
Refinery gas burning	...	540	...	...	x	...
Other	90	...	...	...	x	x
Petroleum marketing:						
Bulk storage (refinery storage not included)	5	...	...	...	...	x
Bulk loading	50	...	...	...	...	x
Other	(2)	...	...	...	...	...
Petroleum production	225	...	...	...	...	...
Metals:						
Nonferrous	...	...	...	...	75	x
Ferrous:						
Gray iron cupolas	...	...	...	x	7	...
Electric steel furnaces	...	...	...	...	7	...
Open hearth furnaces	...	...	...	...	6	...
Other	...	...	...	...	x	...
Chemical:						
Sulfur and sulfuric acid	...	25	...	...	x	x
Other	20	...	...	...	20	x
Mineral:						
Asphalt batching	...	...	...	...	25	...
Asphalt saturators	5	...	...	...	2	...
Other	...	...	...	...	105	...
Organic solvent uses:						
Paint bake ovens	19	...	...	...	x	x
Other	1	...	...	...	x	x
Miscellaneous	...	...	...	...	15	x
Total (rounded)	1, 150	1, 160	170	1, 635	380	x
Total (rounded), 4,500 tons/day.						

[1] During effective period of Rule 62.
[2] Contaminant not capable of being measured quantitatively.

levels. In addition, there are two types of stationary sources still to be improved upon.

One of these involves every facet of community life—the use of organic solvents, diluents, and thinners (*12–14*). The use of these organic solvents is responsible for 450 tons of hydrocarbons and other organic gases, which is approximately 20 percent of the total hydrocarbons now emitted from all sources, including motor vehicles (*15*).

The other remaining stationary source requiring additional attention is the use of fuel oil (*16, 17*). At the present time, the use of high-sulfur fuels is prohibited for 7 months each year, so that, in effect, consumers of large quantities of fuel are required to utilize natural gas (*18*). It is hoped that additional supplies of natural gas can be made available to Los Angeles County so that the extension of this control will be possible. The present state of the art dictates substituting natural gas for fuel oil as the only feasible method of control for this air pollution source. Much engineering research and development remain to be accomplished in the design and adaptation of control devices to large fuel-burning installations. Progress to date indi-

TABLE 2.—*Emissions of contaminants into the Los Angeles County atmosphere from stationary sources, 1948 and 1962*

	Average daily emissions of air contaminants, in tons per day											
	Hydrocarbons and other organic gases		Oxides of nitrogen		Oxides of sulfur		Carbon monoxide		Other inorganic gases		Aerosols	
	1948	1962	1948	1962	1948	1962	1948	1962	1948	1962	1948	1962
Petroleum:												
Refining	450	87	7	1	30	36	570	50	3	4	8	5
Marketing	155	100	0	0	0	0	0	0	0	0	0	0
Production	270	60	u	u	n	n	u	u	0	0	0	0
Organic solvent uses:												
Surface coating	170	260	0	0	0	0	0	0	0	0	2	7
Drycleaning	30	28	0	0	0	0	0	0	0	0	n	0
Degreasing	35	60	0	0	0	0	0	0	0	0	0	n
Plastics and rubber	15	24	0	0	0	0	0	0	0	0	n	n
Other	60	77	0	0	0	0	0	0	0	0	n	n
Combustion of fuels:												
(*a*) Liquid	4	7	140	165	300	400	1	n	n	0	27	32
Gaseous	11	8	90	165	220	8	1	1	n	0	8	14
(*b*) Liquid	na	0	na	10	na	6	na	0	na	0	na	2
Gaseous	na	9	na	200	na	10	na	1	na	0	na	12
Incineration	100	4	20	4	20	1	145	4	n	n	185	4
Chemical:												
Sulfur plants	0	0	n	n	0	27	0	0	0	0	0	0
Sulfuric acid plants	0	0	n	n	15	24	0	0	0	0	n	n
Other	25	40	n	n	1	1	0	0	n	1	12	8
Metals	0	0	0	3	n	n	325	180	0	0	25	6
Minerals	2	2	0	6	n	0	u	0	0	0	4	4
Miscellaneous	u	u	0	0	u	u	0	0	u	u	u	2
Total (rounded):												
(*a*)	1325	760	260	350	585	495	1040	235	3	5	270	80
(*b*)	......	740	......	220	......	105	......	235	......	5	......	50

(*a*) Average emissions during period Rule 62 not in effect.
(*b*) Average emissions during effective period of Rule 62.
na—Not applicable.
0—<0. 05 ton per day.
n—Negligible (0.05–0.5 ton per day).
u—Unknown.

cates that the effluent from such sources can be controlled successfully.

The prohibitions contained in the rules and regulations of the Los Angeles County Air Pollution Control District are believed to be the most stringent anywhere in the world. These rules govern smoke, nuisance, particulate matter, sulfur compounds, combustion contaminants, dusts and fumes, open fires, incinerator burning, storage of petroleum products, oil effluent-water separators, gasoline loading, sulfur content of fuels, gasoline composition, and animal reduction processes.

It can be seen from this impressive list that the rules and regulations affect the operation of every industry, almost every commercial endeavor, and in at least one direct aspect, every homeowner in Los Angeles County. Through their enforcement, controls have been applied to such diverse sources and operations as incinerators, rendering cookers, coffee roasters, petroleum refineries, chemical plants, rock crushers, asphalt plants, open hearth furnaces, electric furnaces, and automobile assembly plants, as well as less obvious uses such as restaurants, crematories, and housing tract developers. From the smelting of metal to the production of dog food, air-pollution-prone operations have been brought within the scope of the control program.

The types of control devices installed vary widely in cost and collection efficiency. Among these are electric precipitators, baghouses, afterburners, separators, scrubbers, absorbers, adsorbers, and various types of vapor collection equipment. Each type of device possesses advantages and limitations that must be considered carefully. Each source poses different problems in terms of volume, temperature, and characteristics of the waste emitted from it. The degree of control which a community requires will dictate, in the main, which type of control device will be utilized and, hence, the cost of the control system.

Table 3 gives a list of typical basic and control equipment installed in Los Angeles County over the past 14 years. In some cases, the cost of the control equipment is but a small fraction of the cost of the production equipment. In other cases, the cost of control equipment is greater than the cost of the basic equipment.

TABLE 3.—*Typical costs of basic and control equipment installed in Los Angeles County*

Source	Size of equipment	Cost of basic equipment	Type of control equipment	Cost of control equipment
Airblown asphalt system	500 bbls./batch	$10, 500	Afterburner	$3, 000
Asphalt concrete batching plant	200,000 lbs./hr	150, 000	Scrubber	10, 000
Asphalt saturator	6 by 65 by 8 ft	40, 000	Scrubber and electric precipitator.	50, 000
Asphalt tile production	5,000 lbs./hr	150, 000	Baghouse	5, 000
Borax drying and classifying	10,000 lbs./hr	1, 000, 000	Baghouse and scrubber	10, 000
Bulk gasoline loading rack	667,000 gals./day	88, 000	Vapor control system	50, 000
Carbon black plant	2,000 gals./day	5, 000	Baghouse	5, 000
Catalytic reforming unit	2,400 bbls./day	265, 000	Flare and sour water oxidizer.	6, 000
Ceramic tile production	8,000 lbs./hr	200, 000	Scrubber	10, 000
Chip dryer, aluminum	2,500 lbs./hr	3, 000	Afterburner	3, 000
Chrome plating	4 by 5 by 5 ft	2, 000	Scrubber	800
Coffee roaster	3 tons/hr	35, 000	Cyclone and afterburner	8, 000
Concrete batching plant	900,000 lbs./hr	125, 000	Baghouse	10, 000
Core oven	8 by 8 by 12 ft	4, 000	Afterburner	1, 500
Crucible furnace, yellow brass	4 furnaces @ 850 lbs. each/heat.	[1] 2, 500	Baghouse	17, 000
Crude oil distillation unit	37,000 bbls./hr	3, 060, 000	Vapor control system	10, 000
Cupola, gray iron	48″ ID	40, 000	Baghouse and quench tank	67, 000
	27″ ID	25, 000	.....do	32, 000
Debonder	500 brake shoes/hr	1, 800	Afterburner	300
Deep fat fryer, food	1,000 lbs./hr	15, 000	.....do	1, 500
Delayed coker unit	9,300 bbls./day	4, 000, 000	Scrubber (serving 3 cokers)	385, 000
Drum reclamation incinerator	60 bbls./hr	10, 000	Afterburner	2, 000
	200 bbls./hr	25, 000	.....do	5, 000
Electric arc furnace, steel	18 tons/heat	75, 000	Baghouse	45, 000
Electric induction furnace, brass	2, 000 lbs./hr	75, 000	.....do	2, 700
Enamel frit drying	1, 500 lbs./hr	25, 000	.....do	3, 000
Fiberboard production	32,000 lbs./hr	10, 000	Electric precipitator	15, 000
Fire-retardant manufacturing	1,000 lbs./hr	25, 000	Baghouse	2, 000
Fixed roof storage tank for gasoline	80,000 bbls	50, 000	New floating roof tank	132, 000
Flue-fed incinerator	Most sizes	4, 000–7, 000	Afterburner	2, 500
Fluid catalytic cracking unit	40,000 bbls./day	7, 460, 000	Electric precipitator	1, 040, 000
			CO boiler	1, 770, 000
			Cyclones	165, 000
			Blowdown systems, vapor manifold, and flare.	363, 000
	7,400 bbls./day	1, 747, 500	Electric precipitator, vapor manifold, and flare.	131, 000
Galvanizing kettle	4 by 30 by 4 ft	25, 000	Baghouse	3, 000
Gritblasting machine	6 cu. ft	9, 300	.....do	1, 700

[1] Each.

TABLE 3.—*Typical costs of basic and control equipment installed in Los Angeles County*—Continued

Source	Size of equipment	Cost of basic equipment	Type of control equipment	Cost of control equipment
Insecticide manufacturing	1,000 lbs./hr	10, 000	.....do	3, 000
Insulation production, including cupola, blow chamber, and curing oven.	5,000 lbs./hr	13, 000	Baghouse, scrubber, and afterburner.	30, 000
Liquid hydrogen manufacturing	32 tons/yr	8, 392, 000	Flare	17, 700
Lithographing oven	240 ft./min	78, 000	Afterburner	15, 000
Multiple-chamber incinerator, industrial and commercial.	50 lbs./hr	800		......
	500 lbs./hr	6, 500		......
	6000 lbs./hr	75, 000		......
Multiple-chamber incinerator, pathological.	50 lbs./hr	1, 000		......
	200 lbs./hr	4, 500		......
Multiple-chamber incinerator, wire reclamation.	100 lbs./hr	1, 200		......
	1,000 lbs./hr	15, 000		......
Multiple-chamber incinerator, with continuous feed bin.	250 lbs./hr	5, 000		......
	3,000 lbs./hr	45, 000		......
Natural gas plant	20,000,000 cu. ft./day	220, 000	Vapor manifold and flare	5, 000
Oil-water separator	300,000 bbls./day	170, 000	Floating roof	80, 000
	350 bbls./day	17, 000	Cover	700
	3,500 bbls./day	32, 000	Floating roof	8, 000
Open hearth furnace, steel	60 tons/heat	200, 000	Electric precipitator	150, 000
Phosphate fertilizer production	2,000 lbs./hr	10, 000	Baghouse	5, 000
Phthalic anhydride manufacturing plant.	25,000,000 lbs./yr	1, 200, 000	Afterburner and baghouse	195, 000
Pipe coating, including spinning, wrapping, and dipping.	4–10 lengths/hr	23, 500	Scrubbers	32, 000
Pneumatic conveyors (minerals)	200 to 5,000 lbs./hr	2, 000	Cyclone and baghouse	2, 000
Pot furnace, type metal	16,000 lbs	9, 000	Afterburner	3, 000
Rendered grease processing	6 tons/day	10, 000	Contact condenser and afterburner.	2, 500
Rendering cooker and drier (batch)	4 tons/batch	10, 000	Surface condenser and afterburner.	15, 000
Rendering cooker system (continuous).	15 tons/hr	100, 000	.....do	25, 000
Rock crushing and sizing	300,000 lbs./hr	75, 000	Scrubber	2, 000
Rotogravure press	5-color, 44-inch web	340, 000	Activated carbon filter	40, 000
Rubber Banbury mixer	1,000 lbs./hr	25, 000	Baghouse	3, 000
Sandblast room	8 by 12 by 8 ft	1, 600	.....do	3, 000
Sewage treatment digestion	900,000 gals./day	800, 000	Water seals and flares	7, 000
Sewage treatment headworks	250,000,000 gals./day	550, 000	Covers	20, 000
Sewage water reclamation	17,000,000 gals./day	1, 500, 000	Covers and aeration tanks	25, 000
Sewer pipe manufacturing	20,000 lbs./hr	1, 000, 000	Baghouse	10, 000
Ship bulk loading	2,500 tons/hr	500, 000	.....do	168, 000
Smoke generator and smokehouse	11 by 14 by 11 ft	18, 000	Precipitator, scrubber, and afterburner.	42, 000
Sulfuric acid plant	250 tons/day	1, 900, 000	Electrostatic precipitator	150, 000
Sulfur recovery plant	2 parallel units, 65 tons/day, each.	1, 400, 000	Incinerator	30, 000
	10 tons/day	265, 000	.....do	5, 000
	2, 840 lbs./day	30, 000	.....do	1, 000
	8, 000 lbs./day	60, 000	.....do	1, 000
Sweat furnace, aluminum	3, 000 lbs./hr	3, 500	Afterburner and baghouse	3, 500
Synthetic rubber manufacturing	30, 000 tons/yr	1, 600, 000	Vapor manifold and flare	250, 000
Synthetic solvent dry cleaner	60 lbs./batch	14, 000	Activated carbon filter	3, 000
Varnish cookers (2)	250 gallons each	4, 000	Afterburner	5, 500
Wallboard production	60, 000 lbs./hr	1, 500, 000	Baghouse	100, 000

So far, the status of engineering knowledge has been discussed as applied to control of the stationary source. Elsewhere during this Conference the motor vehicle will have been discussed in some detail. The position of the district in the field of motor vehicle research and control makes it possible to address, from a unique vantage point, a few remarks to the subject of the status of engineering knowledge as applied to the control of the vehicular source.

At the same time that the engineering and enforcement programs of the district were directed at stationary sources, research also was performed to determine the role gasoline-powered vehicles played in the formation of photochemical smog. That research is now completed, and the results have been confirmed by many other researchers.

To indicate the magnitude of the problem, in 1962 the 3.4 million vehicles in Los Angeles County consumed a daily total of 6.6 million gallons of gasoline, resulting in emissions to the atmosphere of some 8,600 tons of air contaminants. This figure is indeed startling when it is realized that only 1,400 tons of contaminants were emitted from vehicles in Los Angeles County in 1948. (See table 4.)

As a result of laws passed by the California State Legislature in 1959 and 1960, the State of California has occupied the field in assuming responsibility for control of the motor vehicle. Under these laws, the Motor Vehicle Pollution Control Board has jurisdiction over vehicular emissions in that it tests and certifies vehicle control devices, while the Department of Public Health has jurisdiction over health aspects, as well as the responsibility for establishing standards for air quality and motor vehicle exhausts.

Since the establishment of the Motor Vehicle Pollution Control Board 2 years ago, this 13-man group has established criteria for both crankcase and exhaust control devices. Within the past year, the board has approved nine crankcase devices and has started testing exhaust devices. Crankcase emission control systems already have been installed on most new cars sold in California since 1961. American automobile makers have agreed to equip all 1963 models manufactured in the United States with California-approved crankcase control systems.

At the same time, great progress has been made by the automobile manufacturers in their attempts to reduce exhaust emissions by modifying the internal combustion engine rather than by adding additional hardware to the exhaust system. Within 2 years, California motorists may be able to have new cars delivered to them with the engine modified sufficiently for the exhaust emissions to conform to the California State Standards for Clean Air. In such an event, no additional exhaust control device would be necessary, and the California motorist would be relieved of a potential bill of some $1

TABLE 4.—*Emissions of contaminants into Los Angeles County atmosphere from motor vehicles, 1948 and 1962*

Source	Average daily emissions of air contaminants, in tons per day											
	Hydrocarbons and other organic gases		Oxides of nitrogen		Oxides of sulfur		Carbon monoxide		Other inorganic gases		Aerosols	
	1948	1962 [1]	1948	1962 [1]	1948	1962	1948	1962 [1]	1948	1962	1948	1962
Automobiles [2]	545	1,110	230	464	29	19	2,500	5,040	2	n	14	29
Trucks and busses (gasoline).	115	235	70	141	18	6	760	1,540	n	n	5	9
Trucks and busses (diesel)	6	8	6	8	1	2	2	2	0	n	2	2
Total (rounded)	670	1,350	310	615	50	25	3,260	6,580	2	n	20	40

[1] These emissions are subject to confirmation by the current joint survey by Los Angeles County Air Pollution Control District, U.S. Public Health Service, California Health Department, Automobile Manufacturers Association, and Automobile Club of Southern California.

[2] Includes trucks under 4,000 pounds unladen weight.

n—Negligible (0.05-0.5 ton per day).

0—<0.05 ton per day.

billion. The modified-engine approach undoubtedly would be a superior engineering and economic solution.

But neither this nor any other solution to the motor vehicle problem, or any other air pollution problem, could have been envisioned, much less developed, if the public, the control agency, and the government officials had not demanded action, accepted their responsibilities, and worked to find the solutions.

From our experiences over the years we can draw two important conclusions. First, the technical know-how and the actual control devices are now available for the control of almost any air pollution problem arising from stationary sources and soon will be available for the control of vehicular sources. Second, each community must determine for itself the degree of clean air it desires and the price it is willing to pay for that degree of clean air.

In Los Angeles, the price has been high because the control program was a pioneering effort. The price in other areas should be much lower because of that effort. Results, answers, and techniques now are available that can be of benefit to other areas. The experiences in Los Angeles need not be repeated in every urbanized area which has an air pollution problem. The mistakes and accomplishments in Los Angeles should prove valuable guidelines for other areas to follow. The price any community pays, therefore, for clean air should be far less than it has been for Los Angeles.

No longer is there any need to ask, "Can air pollution be controlled?"

No longer is there any need to ask, "Must air pollution be controlled?"

Each of us in our own communities needs only to ask, "How much control do we need, and how much are we willing to pay?"

Having answered these questions, it will be found that the status of engineering knowledge for the control of air pollution is such that the answers to most of the remaining questions will be found readily available.

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Rule 62. Sulfur Contents of Fuels. A person shall not burn within the Los Angeles Basin at any time between May 1 and September 30, both dates inclusive, during the calendar year 1959, and each year thereafter between April 15 and November 15, both inclusive, of the same calendar year, any gaseous fuel containing sulfur compounds in excess of 50 grains per 100 cubic feet of gaseous fuel, calculated as hydrogen sulfide at standard conditions, or any liquid fuel or solid fuel having a sulfur content in excess of 0.5 per cent by weight.

The provisions of this rule shall not apply to—

a. The burning of sulfur, hydrogen sulfide, acid sludge or other sulfur compounds in the manufacturing of sulfur or sulfur compounds.

b. The incinerating of waste gases provided that the gross heating value of such gases is less than 300 British thermal units per cubic foot at standard conditions and the fuel used to incinerate such waste gases does not contain sulfur or sulfur compounds in excess of the amount specified in this rule.

c. The use of solid fuels in any metallurgical process.

d. The use of fuels where the gaseous products of combustion are used as raw materials for other processes.

e. The use of liquid or solid fuel to propel or test any vehicle, aircraft, missile, locomotive, boat or ship.

f. The use of liquid fuel whenever the supply of gaseous fuel, the burning of which is permited by this rule, is not physically available to the user due to accident, act of God, act of war, act of the public enemy, or failure of the supplier.

Prepared Discussion: THE STATUS OF ENGINEERING KNOWLEDGE FOR THE CONTROL OF AIR POLLUTION [1]

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Mr. Chass' statement that "each community must determine for itself the degree of clean air it desires and the price it is willing to pay for that degree of clean air" is very significant. How much control do we need and how much are we willing to pay? While most emissions can be controlled to nearly 100 percent, the cost can be enormous.

Let's face facts. From the practical standpoint the cost of control versus the degree of control to be provided frequently requires that some compromise be made.

Some of the factors which must be considerd in this compromise are cost of operation, need for special materials of construction, frequency and dependability of operation, the location of the source in respect to the receptor, and the possible effects on the receptor, whether it be human, plant, or inanimate.

The control of existing sources of air pollution more often than not involves the installation of supplementary equipment to reduce the amount of contaminants being discharged. Such supplementary equipment may fall into one or more of a number of classes, such as gravitation, inertial separation, filtration, wet collection, electrostatic precipitation, absorption and adsorption, incineration, and catalytic combustion. Aside from mentioning these, however, I am not going to discuss their design characteristics, performance, or potential efficiencies for treating various types of emissions.

Integral controls, on the other hand, are controls particularly during the planning and development stages of a new process. The process must be designed, engineered, and located to minimize air contaminant emissions and effects. It may involve such things as the materials, chemicals, or fuels to be used in a process, the design of process equipment, and a study of the most desirable location from the point of view of minimum effects on the receptor. In essence, what I am saying is that air pollution control should never be an afterthought. When any process is designed or redesigned to reduce air contaminant emissions—and this is equally true of industrial as well as domestic sources—integral control measures should receive the attention they deserve.

For example, in New York State, when plans, specifications, or reports on proposed installations are reviewed, careful consideration is given to such factors as topography, meteorology, point of emission, and nearby community activities, as well as to the process itself and the controls to be provided. These integral controls are equally as important as supplementary controls.

By no means do I wish to imply that Mr. Chass is not in agreement with these views or that these practices are not carried out also in California. In fact, Mr. Chass in his paper gave an example of integral controls when speaking about the emissions from internal combustion engines. He alluded to the fact that great progress has been made by the automobile manufacturers in their attempt to re-

duce exhaust emissions by modifying the internal combustion engine rather than by adding additional hardware to the exhaust system. He stated that "the modified-engine approach undoubtedly would be a superior engineering and economic solution."

A recent report from the World Health Organization points in a more convincing manner than I can muster here to the strong interrelationship among source location or planning, meteorology, and the health effects of air pollution. The World Health Organization reports that in London the highest incidence of cancer of the lung was found in the northeast sector of the city, where the prevailing winds brought air pollution from the center and the south of the city. (Public Health Papers No. 15.)

I must emphasize again that economic consideration often plays a large part in arriving at a rational solution to a problem. For example, Mr. Chass said that "no longer is it necessary to cast doubt on the desirability of having pollution-free, cut-and-cover sanitary landfills, rather than smoky, dusty municipal incinerators." While from the technical viewpoint this is true, in that fewer air contaminants will be emitted from a properly operated landfill than from a poorly operated incinerator, it must be recognized also that sprawling urbanization is rapidly reducing potential areas for sanitary landfills around our larger, and many of our smaller, cities. Depending on specific local conditions, incinerators or methods not yet devised may be the only practical solution for satisfactory refuse disposal. It also must be pointed out that operation plays a large part in the control of emissions, whether these emissions are from a sanitary landfill or a municipal incinerator. Both sanitary landfills and incinerators, if improperly operated, can become smoky, dusty operations. How we dispose of our refuse is not as important as disposing of it in a satisfactory manner.

An important point to keep in mind in the control of air pollution is not knowing how many tons of contaminants are being prevented from entering the atmosphere, but knowing whether the contamination present in an atmosphere is at or below a satisfactory level. The status of engineering knowledge has advanced to the point at which—once the community has determined the air quality which it wishes to maintain—engineering controls, both integral and supplementary, can be devised to attain the desired objective.

Engineers working in cooperation with representatives of other scientific disciplines, such as meteorologists, physicians, plant specialists, professional planners, and economists, can assist any community in determining the degree of clean air it desires. This involves long-range planning considerations, subject to change as developments occur. Meanwhile, effort should be aimed at controlling those sources for which there is the greatest need for control and for which the greatest control result can be achieved with the least expenditure.

HOW CAN WE BETTER COORDINATE PUBLIC AND PRIVATE EFFORTS TO ACHIEVE A BROADER AND MORE EFFECTIVE APPLICATION OF CONTROL TECHNIQUES?

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Careful reflection on the title assigned to me leads to the observation that I need not feel "fenced in"; the scope is very broad and is in keeping with the limitlessness of many things in this, the space age. It is a subject on which rather little has been written, and if my interpretation of its scope is correct, it deals with an area of interest which deserves much more consideration than it has received. At the same time, I am happy to say that there has been a marked change for the better during recent years.

There are many things that might be done to accomplish improved coordination of our efforts in air pollution control. Some of the more important ones are:

1. Expanding the knowledge and understanding of air pollution control officials, control engineers, city planners, politicians, meteorologists, and chemists, especially in the way of broadening their scope of understanding.
2. Improving the dissemination of all technical information to all persons in the field who are capable of putting it to beneficial use.
3. Evaluating, redefining, and emphasizing the responsibilities of control officials, process engineers, equipment manufacturers, research personnel, consulting engineers, and others who are making significant contributions to the total effort.

When one analyzes carefully and objectively the many facets and ramifications of the subject matter in the light of years of experience in the field, one overriding factor seems to come into sharp focus. It is that the crux of the problem stems largely from a glaring lack of mutual understanding between the regulators and the regulated. Consequently, the remainder of this paper will be devoted to the presentation of evidence which leads to the foregoing conclusion and to a recommended procedure for overcoming the existing deficiency. As a matter of fact, I submit that improving the mutual understanding, respect, and cooperation among all persons involved will achieve wonders in the direction of "clearing the air," not only in terms of reducing the amount of pollutants in the atmosphere, but also in terms of reducing the amount of misinformation on the air waves, in the press, and in the air of public meeting rooms where matters of air pollution are discussed. In other words, the theme of this meeting, "Let's Clear the Air," is capable of at least two interpretations. Improved coordination of the relevant activities and programs in the regulatory agencies with those of the "offenders," and vice versa, in my opinion will do more good to clear the air in either or both interpretations of the Conference theme than any other single item pertaining to the broad and effective application of control techniques.

In any problem area, improved understanding leads to better coordination, and better understanding in turn comes from improved communication. Judging from experience, a very effective way to improve communication among all concerned is to

increase greatly the number of nongovernmental participants, such as knowledgeable industry representatives, on committees, boards, commissions, and other governmental groups which are active in the broad area of air pollution, its evaluation and control. This applies to all levels of government, to all types of commissions, boards, etc., and to all areas of interest, from the drafting of legislation to its administration, from the granting of funds for research to the analysis and application of the findings from such research, and from the planning of investigations to the writing of the reports resulting therefrom. What is more, the nongovernmental members of such boards, commissions, etc., should be full voting members, not merely advisory members, for reasons to be given later. Since regulations affect the comfort, property, and possibly the health of people, on the one hand, and may seriously affect the efficiency or profitability of industry, on the other, there is obvious justification for joint participation in the activities of regulatory bodies at all levels of government.

It was my privilege during the 4-year period from 1956 to 1960 to serve on the Public Health Service Research Grants Study Section on Environmental Sciences and Engineering. Even though the name of that advisory group in 1956 was Sanitary Engineering and Occupational Health, it reviewed and made recommendations as to appropriate action on the application for research grants in the field of air pollution research, as well as in those fields suggested by the name of the study section, as specifically, sanitary engineering in the usual sense, and industrial hygiene. The members of the group numbered about 25 and included 2 or 3, as a rule, who were regarded as being outstandingly competent in each of the many specific areas served by the Study Section. If my memory serves me correctly, I was the only industry-employed member of the committee at any time in the 4-year period, except for the first few meetings, when a representative of a water pollution control equipment manufacturer served. Most of the members came from educational institutions and research foundations, with a smattering from official health agencies and consulting firms.

The funds allotted for research in the field served by the Environmental Sciences and Engineering Study Section, millions of dollars annually, were a significant portion of the total so consumed in the United States. This was especially true in the area of air pollution. In other words, that Study Section played an important role in the entire air pollution measurement and control research activity in the United States. Since industry is an important source of air pollution, is it not logical that it should be represented continuously on such study sections in order that at least some of the many control problems it faces may become the direct target of such research? Membership of competent nongovernmental participants, of course, should not be limited to industry representatives; it should include representation from all segments of commerce, industry, and the public which contribute significant amounts of air pollutants.

My service on the Environmental Sciences and Engineering Research Grants Study Section gave me a better understanding of the many-faceted problems encountered in the equitable allocation of Federal research funds to many and varied applicants. More importantly, however, it served to acquaint the other members of the Section with (1) some of the problem areas in effluent-gas treatment, (2) many of the deficiencies and gaps in the current state of knowledge as regards air-pollutant control, and (3) the huge amount of effort and money spent annually by industry on air pollution control. I recall clearly, for example, how surprised some of the Study Section members were to learn of the huge costs involved in fume control at certain metallurgical operations. It is not difficult to see the great value in better understanding of the other fellow's problems that would result from the much more common use of representatives of the "offenders" on the many types of committees, boards, and commissions that deal with air pollution matters.

An area in which deficiencies in communication have been particularly harmful, and have served to widen the gap of misunderstanding between the regulatory agencies and industry, is that of control equipment failures. Installations of pollutant control devices which measure up to or exceed expectations are reported immediately in many media of communication, including the manufacturer's or vendor's advertising medium. If the installation is unique in any important respect or if it is the first application at a particular pollutant source or gas stream, it is reported in glowing terms in bold type, and makes the headlines in local newspapers. Shortly thereafter a number of the pertinent trade and technical journals publish the story, not infrequently as a feature article. Not so with the failures, of which there are many. They rarely

get any public notice whatsoever. Try to imagine, for example, an equipment manufacturing firm advertising its failures, or even more to the point, the sales engineers of any such firm telling the engineers in a regulatory agency the whole story, when queried as to whether their equipment will work satisfactorily on any given pollutant source. This is not critical of such equipment manufacturers; it simply represents common practice in sales engineering work. While the reasons for the dearth of information regarding failures or other deficiencies may be obvious, the far-reaching and deleterious effects apparently are not.

While news of failures does spread throughout the particular industry affected, largely by word of mouth, the official agencies at all levels of government, the research institutions, the consulting firms, the universities, and the public are very slow to hear of them. This frequently leads to unjustified criticism of industry as "stalling," "being indifferent to the welfare of its neighbors," "failing to cooperate," "being interested only in dollars," and other less sophisticated expressions. The real fact of the matter not infrequently is that the management of any industry or plant is very reluctant to commit a large amount of money for the installation of equipment which is known to have failed or to have created new and unsuspected problems. This is understandable, even though equipment of a similar type may have operated satisfactorily on a comparable operation or source elsewhere. Since (1) air pollution control equipment installations are frightfully costly at many operations, especially in the steel industry; (2) such capital investments almost never improve production or the productive capacity and therefore do not earn a monetary return; and (3) not infrequently the collected material cannot be reused at a financial advantage; it is not difficult to see why management often is hard put to decide what to do about a source of air pollutants.

Much as I dislike dwelling on this point, it has been my experience time and again that representatives of the official agencies, universities, and research institutions will latch on to any report of a successful installation, even though the source of the report may be none other than the equipment manufacturer or vendor, and cling to it doggedly. No amount of contrary experience seems to cause a change in their thinking. This attitude probably stems from a natural characteristic of human beings, namely to believe what one likes to hear. However, it is very disturbing to hear repeatedly, and see reported over and over again, the one example that turned out successfully without any reference to the many that failed miserably or fell far short of expectations. It is hard to understand also why the engineers in the regulatory agencies, who can't help but be cognizant of the reluctance of engineers to tell about engineering failures, are not more willing to accept the reports of failures which do come to their attention. While much has been said, and not without justification, about the need for more trained personnel in the field of air pollution control, I am strongly of the opinion that the need for broader understanding by those currently in the field is much greater than for more men of similarly inadequate knowledge.

Since this area of communication deficiency, specifically air pollution control equipment failures, is vital to the theme of this paper, it seems in order to cite in a very abridged fashion several illustrative examples.

The first application of fume-collecting equipment to open hearth furnaces was that of precipitators at small-capacity cold-charge furnaces at a steel plant in California, more than 10 years ago. The application was a success and it received the usual storm of publicity in newspapers, trade publications, and technical journals. All in all, everyone was led to believe that the answer had been found to fumes from metallurgical furnaces, at least those used in steelmaking. The original was followed closely by other satisfactory applications though in many cases considerable tim[illegible] were needed following startup to r[illegible] even reasonably well (*1, 2*). M[illegible] were made in rapid successi[illegible] tral rather than individ[illegible] common acceptance [illegible] proved precipitator [illegible] to even out the fum[illegible] and the temperatu[illegible] reaching the collect[illegible]

Neverthcless, a ce[illegible] gen-lanced open he[illegible] working satisfactoril[illegible] stream for more tha[illegible] two important resp[illegible] fume-collecting effic[illegible] tance of the perfor[illegible] matter of the pertin[illegible] regulations. (Incid[illegible] in question is in a lo[illegible]

any air pollution control ordinance or regulation.) In the second place, the equipment supplied by the collector equipment manufacturer to handle the collected fume has been so thoroughly unsatisfactory that it has been taken out of use, and removal is effected by dropping the charge directly from the collector hoppers into trucks for transporting to the dumping site for disposal. The manufacturer of the equipment has had a crew of engineers in the steel plant in question constantly since the equipment was placed in operation, but without success as of the time of this writing.

It would be interesting to know how many representatives of regulatory agencies at all levels of government know of this situation. The installation cost was in excess of $5 million and a financially advantageous way has not yet been found to reuse the collected material. Is there any question why other steel plant management is reluctant to rush ahead with similar installations elsewhere? In fact, it is common knowledge among air pollution control personnel in the steel industry that most of the collector installations at open hearth furnaces perform poorly and require much maintenance.

Many other examples of failures might be recounted, but brief references will be made to only one, fume control at electric furnaces in a small steelmaking plant in California (*3*). The first attempt at meeting the requirements of the then newly adopted Los Angeles County ordinance applying to particulate matter (an approach subscribed to by the Los Angeles County Air Pollution Control District (LACAPCD) engineers) consisted of furnace hoods of the so-called inverted frying-pan type to capture the fumes, and a wet-type collector to remove the fumes from the stack gases. The collector was woefully inadequate and the furnace hood required excessive maintenance.

The next step was to install water-jacketed stainless steel furnace hoods and to replace the wet collector with precipitators. This arrangement also fell far short of the mark. The precipitator manufacturer representatives were dumbfounded with low collecting efficiency. According to them, this was the first application of precipitators to electric furnace fumes. After long and concerted study of the problem, it was concluded that the reason for the failure must be the dryness of the fume-laden gases escaping from the furnace, there being no fuel combustion in the electric furnaces to produce moisture, as is the case in open hearths, for instance.

Consequently, gas-conditioning towers were installed in the system upstream from the precipitators to add moisture to the furnace gases. This solved the collector efficiency problem, but hood maintenance difficulties continue to plague the operators. To surmount this obstacle, furnace roof evacuation was substituted for the furnace hoods.

At last it appeared the goal had been reached, but alas, this was not so. The furnaces in question are top-charged, as are most electric furnaces. Therefore, since the roof must be swung aside for charging, there was no fume, smoke, or dust control operating during the charging cycle, and this resulted in a violation of certain provisions of the Los Angeles regulations.

Following years of experimental work, and consultation with one of the outstanding engineering research and consulting firms in the United States, during all of which time the plant in question operated under variances granted and renewed periodically by the LACAPCD, a possible solution was found to this knotty problem. The roof of the melt shop was converted into a huge catch-basin or reservoir from which the dirty air is withdrawn continuously at the rate of 250,000 cubic feet per minute and cleaned by means of a tremendous bag house collector erected on the roof of the building. While this arrangement has been reasonably effective in achieving compliance with the regulations, it created serious visibility and exposure problems in the shop, which even at this date have not been resolved satisfactorily. Forgetting about the new problem created and still to be solved, it has taken about 10 years of continuing effort and change and about a million dollars in cost to accomplish air pollution control at the steelmaking operations of this small plant. What is more, this investment has not added one iota to the productive capacity or efficiency of the plant, but on the contrary has added an operating cost, and a rather heavy one at that, since the precipitators require an excessive amount of maintenance to keep them operating reasonably well.

The point I want to make, because in my opinion it is the crux of the matter, is that there is a serious lack of understanding of industry's problems on the part of personnel of the official agencies, of some universities and research institutions of all kinds, and of many consulting engineering firms. The very fact that any affected industry or plant is regarded with suspicion and branded as being uncooperative, as soon as it offers a reason for not

rushing headlong into the installation of extremely expensive air pollution control equipment, serves only to widen the gap of misunderstanding because it puts an end to sincere and effective communication.

What, then, can be done to improve communication between the regulators and those regulated, to the end that more effective and broader application of control techniques will result? It is my firm conviction that the most effective first step in that direction is for all regulatory agencies, whether they be in political entities such as towns, cities, counties, States, or the Federal Government, or in large artificial districts such as the Bay Area Air Pollution Control District, or in the Detroit-Windsor area which is international in scope, to include competent nongovernmental personnel on their air pollution committees, commissions, and boards of all types. In addition to providing the climate and mechanism for improved communication, it will result in (1) making available to the regulatory agency representatives much technical know-how unobtainable in any other way, and (2) bringing the nongovernmental participants face to face with some of the administrative and other problems of the official agency personnel.

Before exploring some of the tremendous possibilities that exist in this area of improved communication and the more effective coordination of the efforts of all concerned, it may not be amiss to point out that I speak from experience; this is not an exercise in stargazing, daydreaming, mental gymnastics, or wishful thinking. Before joining the Bethlehem Steel Co., I served for 6 years as an engineering officer in the Commissioned Corps of the Public Health Service. I was in the Industrial Hygiene Division, which at that time handled air pollution matters in addition to those coming within the scope of the current Occupational Health Division. What is more, it has been my privilege during my affiliation with industry to continue to serve on governmental boards, commissions, and committees of many kinds. Pertinent to this discussion are these: the Public Health Service Research Grants Study Section on Environmental Sciences and Engineering mentioned earlier, the Pennsylvania Air Pollution Commission of which I am currently the vice-chairman, and the Technical Advisory Council to the New York State Air Pollution Board of which I am chairman. In other words, I have had experience with a regulatory agency as well as with industry, and continue to have firsthand experience of a dual nature. Hence, the discussion and recommendations that follow have a basis in reality.

It is axiomatic that the more knowledge or information possessed by an individual or a group of persons, the better equipped is that person or group to come to a sound decision on any problem. Equally obvious is the fact that the broader the base of such information or knowledge, the sounder will be the decision. Add to this the fact that the offender, whether it be an industry, a community, or a private citizen, will have more confidence in a decision reached by a broad-based group than in a decision by representatives of the regulatory agency only, and it becomes evident that much is to be gained by including nongovernmental people on all governmental boards, commissions, committees, etc., which deal with air pollution matters. Why then is it not more common for such agencies to count nongovernmental representatives among the members of their boards, commissions, etc.?

The answer to that question is not clear, though one of the contributing factors undoubtedly is the feeling on the part of the regulatory agency personnel that including representatives of those being regulated will retard or even stall progress, especially if such representatives are full voting members of the group. That such feeling exists is evidenced by the fact that advisory groups which include or are exclusively nongovernmental persons are much more common than are regulatory boards and committees which include nongovernmental members with power to vote. Furthermore, I have been faced on more than one occasion with the argument that the right to vote does not add anything to the value growing out of having nongovernmental participants on such governmental agencies. That is to say, the benefits of added know-how, improved communication, cross-fertilization, and better mutual understanding, do not depend on the voting privilege. That this is true can hardly be denied. The advantage deriving from full membership may not be obvious, though it is very real. It stems from the increased confidence industry has in the decisions and mandates issued by a governmental agency which includes industry representatives who were a party to the act, as full partners, not merely as second-class citizens. In other words, it removes the curse that comes from "taxation without representation." More than a few examples might be cited to show how effective a control program can be which is planned and carried out by a joint team of regulatory agency personnel and representatives

of those being regulated. What is more, there is an atmosphere of mutual understanding and respect and of whole-hearted cooperation between the regulatory agency personnel and the regulated that does not otherwise exist, to my knowledge. The situation is quite different from that prevailing when an ill-informed Board of County Supervisors, to pick an example, in the face of well-meant and sincere opposition, adopts an ordinance borrowed lock, stock, and barrel from some other community where conditions are entirely different.

Examples of progressive air pollution control programs which include, and depend heavily upon, nongovernmental members on the rules-drafting and/or administering bodies are the Allegheny County, the New York State, and the Pennsylvania State programs, to cite but a few. Incidentally, the mixed-team approach has been used successfully also in stream pollution control, in in-plant air contamination control, and in ionizing radiation control, in some States. Those wishing to get a more complete picture of joint industry-government activity in the development of air pollution control regulations in one large industrial State should refer to the Monitor for May 1962 (*4*). Surely, the progress of the Pennsylvania, New York, and Allegheny County agencies, in terms of effective long-range programs, is at least as good as that of highly-publicized Los Angeles County and the Bay Area, where the regulations are especially harsh and unyielding. In fact, the contrast between the Allegheny County and the Los Angeles County programs when considered in terms of administrative procedure, money spent by the regulatory agency, time in effect, and results accomplished, provides mute testimony to the fact that mutual understanding, respect, and cooperation go a long way toward bringing about air pollution control on a sensible, practical, progressive, and effective basis.

Industry, in the main, is genuinely interested in reducing the amount of pollutants it discharges to the outside air. This may sound strange to some, but there is abundant evidence to show that it is true. Referring to the steel industry, for example, since I am better acquainted with it than with any other, there has been tremendous progress in the direction of air pollution control since the close of World War II. It is difficult to hazard a guess as to the improvement achieved, but there is little doubt that if Bethlehem is representative of the industry in this respect, the amount of particulate matter released to the air by the industry as a whole is less than half of what it was in 1946, notwithstanding an increase in the production rate. This is not to say that each individual plant has made such improvement. Some have done very well and others not so well. Let me hasten to add that much of the improvement was achieved in the absence of regulations requiring it.

Where health is a bona fide matter of concern, industry is not opposed to a crash program of improvement. However, because of the tremendous costs involved and the operating deficiencies being experienced in control equipment for some pollutant sources, industry is forced to look askance at any crash program where only a nuisance problem is involved. Therefore, in the interest of getting a good job done at a minimum in cost, hardship, and inconvenience to all concerned, it behooves the regulatory agencies to think in terms of well-planned, long-range programs of air pollution control in those air pollution problem areas where established health effects are not a factor. This can be done smoothly and expeditiously by calling upon qualified nongovernmental personnel to serve on air pollution boards, commissions, and committees of all kinds.

In conclusion, I believe it worth the hazards attending repetition to reemphasize several salient points.

1. In achieving the broader application of control techniques to air pollution sources, there is no substitute for mutual understanding and respect between the regulatory agency personnel and those regulated, and for the wholesome cooperation which stems from such mutual respect and understanding.

2. Mutual understanding, respect, and cooperation originate in and flourish on joint effort and activity, whatever may be the nature of the problem involved.

3. Official air pollution agencies of all kinds—planning, investigating, and regulatory—should seek the advice, help, and counsel of qualified representatives of those being regulated, and should include such persons as full partners on all boards, commissions, and committees. The improvement in mutual respect, understanding, and cooperation resulting from such joint effort will go a long way toward achieving air pollution control on a long-range and down-to-earth, but at the same time effec-

tive, basis and at a minimum in cost, hardship, and inconvenience to all concerned.

4. Going back now to the title of this paper, the answer is that the best first step toward better coordination of public and private efforts to achieve a broader and more effective application of control techniques is to improve the communication, understanding, respect, and cooperation between the regulators and the regulated. The most effective way to do this, in my opinion, is to implement the suggestion given in the preceding paragraph.

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DINATE PUBLIC AND PRIVATE EFFORTS TO ACHIEVE A BROADER AND MORE EFFECTIVE APPLICATION OF CONTROL TECHNIQUES? [1]

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The title of this conference and the subject of Dr. Brandt's paper imply at least two things: (1) that the air needs cleaning, and (2) that better coordination of public and private efforts is needed to accomplish this. With regard to the first, I doubt that any speaker at this conference will question the need for "clearing the air" or that any will belittle in any way the magnitude and seriousness of the problem. Clear air, or clean air, is a desirable objective. There seems to be general accord on this point. If this were the paramount objective of society and if actions were taken accordingly, achievement of effective air pollution control would be greatly simplified.

The need and desire for clearing the air is only one of the many needs and desires of our complex society, though admittedly one that until recent years failed to receive due attention. Belated attention to the air resource during a period of rapid industrialization and urbanization of the country inevitably resulted in almost intolerable air pollution conditions in many localities. Relief through private litigation against offenders was not up to the task of protection of the public from the effects of air pollution. To meet public needs and to provide an administrative framework for achieving a rational balance between the biologic and economic needs for clean air, regulatory legislation became a necessity. In view of the intrenched air pollution problems that usually face new regulatory agencies and the necessity for dealing with newly emerging ones, I believe that creditable progress has been made in recent years. The nature and extent of major local and regional air pollution problems have been defined. Abatement and preventive requirements to achieve and maintain adequate control have been determined for many areas. The many noteworthy applications of control techniques that have been made, however, even by most liberal estimates, represent only a modest attack on the total problem. The really tough part of the job—universal application of effective control techniques—lies ahead.

Dr. Brandt's resumé of some control experience of the steel industry is illustrative of the administrative and technical difficulties involved. He offers a specific suggestion as a means for overcoming or minimizing these difficulties, namely, that "all regulatory agencies . . . include competent nongovernmental personnel on their air pollution committees, commissions, and boards of all types." Many regulatory organizations are so constituted.[2] Whether their achievements are so outstandingly superior as to justify universal adoption would appear to be open to question. Regions apparently have adopted legislation and established administrative organizations to best meet their specific air pollution control

[1] Read by Fred W. Thomas.

[2] A Digest of State Air Pollution Laws—1960 edition and 1961 supplement—U.S. Department of Health, Education, and Welfare, Public Health Service.

and administrative arrangements for effective coordination of air pollution efforts. Coordination of public and private efforts apparently receives high priority in most, if not all, statutory air pollution control programs. A fair question one might ask is whether or not coordination has become such a fetish that a disproportional amount of top-level staff time is devoted to "coordination" which might be more profitably devoted to finding solutions to specific technical and administrative problems. I venture the suggestion that the need is not for better coordination so much as it is for more control effort, both private and public.

Municipalities and public institutions should examine critically activities for which they are directly responsible to assure that good air pollution practices are followed. Many municipalities would fail the test on at least one point because open burning is still a common practice in disposal of garbage and refuse. It is reported that even the Nation's capital is not free from this source of air pollution.[3]

With regard to abatement and control of industrial air pollution, John E. Yocom [4] has succinctly summarized the present situation and outlook as follows:

> At this point, it is no longer fruitful for industry to argue whether or not it should be compelled to make sometimes expensive provisions to reduce plant emissions to the atmosphere. The questions now are: How should control regulations be written and how can compliance best be achieved?

Compel may be a somewhat strong term to use. However, I doubt that any one conversant with the technical and economic problems involved would be naive enough to suggest seriously that persuasion on the part of control agencies and volunteer actions by offenders, to borrow Dr. Brandt's term, will be sufficient to clear the air within any reasonable period of time. Compulsion will doubtless be necessary in some situations, but I believe it is fair highly complex technical data. The attention being given to ambient air quality standards as a basis for control regulations is commendable. Such standards relate control limits to actual significant undesirable effect. Regulations based on ambient air quality rely upon performance standards. They afford maximum flexibility for control to the offending plant or industry, but it remains to be seen if they can be effectively administered. Despite the limitations of and objections to emission design standards, the continued widespread use of and reliance upon such standards for air pollution control is almost a certainty. Thus, air pollution control agencies will continue to be heavily involved in industrial processes as well as in the assessment of effects of industrial air pollution. If the number of technical publications is any indication of the distribution of the total effort on air pollution research and investigation, the preponderance of work has been directed toward measurement and transport of pollution in the atmosphere and intensive research on effects, actual or potential, of air pollution on health and vegetation, and to a lesser extent on property. The needs of regulatory agencies and others for information of this kind appears to be met reasonably well. In contrast, as pointed out by Dr. Brandt, published and readily available information on research on air pollution control techniques and performance of control equipment generally is limited to "success" stories. Even these stories often do not include the kinds of detailed information that would be needed to adapt the experience reported to a new situation. There is a dearth of available information on control equipment limitations, actual performance, and failures. Without complete information, it is difficult if not impossible to arrive at a reasonable balance between clean air objectives and control requirements.

In an effort to develop industrial process and control equipment performance data that will help to fill this gap in available air pollution control information, the Tennessee Valley Authority has recently completed arrangements with the Public Health Service for extensive in-plant air pollution studies in both its chemical plants and its coal-fired, steam-electric generating plants. Studies are to be initiated early in 1963.

[3] According to report "Air Pollution in the National Capital Area," July 1962, by Department of Health, Education, and Welfare, Public Health Service, 400 tons per day of refuse are disposed of by open burning dump.

[4] Yocom, John E., "Air Pollution Regulations—Their Growing Impact on Engineering," July 1962 Chemical Engineering.

HOW CAN WE EXPEDITE THE APPLICATION OF CONTROL TECHNIQUES?

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Just 2 years ago this month, a conference of representatives from most European countries was held in Copenhagen. Its subject was air pollution and its concern was epidemiologic and related research. A report on this symposium, released in 1962, has special pertinence to this U.S. Conference and more particularly to the subject of this paper.

The industrial society of Europe is older than ours. The density of population and of industry is greater. Europe illustrates the complexity, as well as the problem, of a highly urbanized industrial series of regions. In air pollution, its history has both warning and lesson.

The papers presented here make abundantly clear that the European experience and conclusions parallel those emerging in our country. They may be paraphrased in the following terms*, substituting for Europe the experience of the United States:

> Air pollution has been described as one of the worst environmental evils to which the peoples of Europe are exposed. Although in some areas current methods of control are resulting in cleaner air, in others air pollution is increasing both in the chemical complexity of its composition and in the extent of the areas affected.
>
> Researches on air pollution are being undertaken in a number of countries, but many authorities consider that the scientific effort at the present time is too small in relation to the complexity and urgency of the problems involved. It has been suggested that one reason why more support has not been given for this work is that the full pathological effects of air pollution have not been evaluated.

*Epidemiology of Air Pollution, Report on a Symposium, Public Health Papers 15, World Health Organization, Geneva, 1962.

GUIDING PRINCIPLES

Although it may be heartening to realize that we have worldwide company in our dilemma with air pollution and its abatement, this fact does not provide guidance for our policy and decision making. One of the significant lessons of public health history has been that action often preceded complete availability of scientific verification of cause and effect. The progress toward cleaner air would undoubtedly be facilitated by more complete epidemiologic clarification of the relationship between mortality and morbidity and the mounting constituents and concentrations of materials. The accumulation of such evidence is slow. In the meantime, a reasonable basis for expediting the application of control techniques lies in the desire for increased cleanliness, per se, of the air we breathe. Within such a general precept, what are the moves most likely to provide more rapid cleaning and abatement?

SPECIFIC AREAS FOR PROMPT ACTION

Underlying any administrative action must be at least an understanding of the realities of pollution—their amount, geographic variability, change in time, composition and concentration, and origin. This underpinning of fact has had a long and somewhat baffling history. At one stage, the accumulation of such data became an end in itself. Their use as instruments for action dwindled for some years, with significant exceptions in some cities.

Fortunately, this pedestrian sampling has given way in the last 10 years to purposeful network sampling, devised to provide useful guides to de-

vide useful information is that of the statewide co-operative network to monitor air pollutants, instituted by the California Department of Public Health on July 1, 1962. Participating in this undertaking are all the air pollution districts in California, several local health departments, and the U.S. Public Health Service. Such networks for developing information currently are partially in use elsewhere. Their expansion is a prerequisite to understanding the variabilities of discharge and the consequent problems they create. The diagnostic importance of long-term and selective data collection is illustrated by experience in New York City, Pittsburgh, and St. Louis.

The form which such expanding networks will take nationally is contingent, of course, upon the purposes for which sampling is desired. The Public Health Service has already gone through the labors of developing a national network for surveillance of the radioactive components of the atmosphere. It is necessarily geared to the special issues in that field. The principles it illustrates are equally applicable in other air evaluations of national, regional, or local scope.

Coupled with the essential task of collection and interpretation of basic data is the corresponding necessity of assessing the effect of such pollution. It is already clear that such assessments may no longer remain purely gross in character and correlation. What is increasingly demanded are determinations of immediate effects, of those occurring weeks or months later, and most difficult of all, of the chronic or long-term effects of years of exposure. These research functions will only be facilitated when the multidiscipline forces of biologist, chemist, and physicist are linked closely, continuously, and sympathetically with those of the engineer. Simultaneously, the medical officer of health is called upon to sharpen the tools of diagnosis and reporting of disease. In many instances, the quality of medical statistics is inadequate for the epidemiologic necessities underlying the air pollution abatement program.

Week by week, both areas of activity delineated above become strengthened by new work in field and laboratory. Correction of atmospheric blight, however, requires the third leg of the tripod upon which the final results depend. Technologic answers must be developed and applied toward the reduction of discharges, quantitatively as well as urban development. The solutions are neither as simple nor as apparent as in many other environmental impacts. Nonetheless, industrial consciousness and conscience must be stimulated to disclose more rapidly the methods, devices, and control mechanisms more closely geared to the desired level of atmospheric cleanliness.

In all of these approaches, governmental edict alone will not suffice. To governments' functions of research, stimulation, and leadership must be added the values so peculiarly available in universities, private research units, and industrial research and development facilities. Without these, progress will be slow.

SOME EXAMPLES OF SUCCESSFUL CONTROL

The listing of methods of resolving environmental problems can result in frustration and pessimism. Their number and complexity are often so great as almost to intimidate the newcomer. Despair, however, is unnecessary. Even in air pollution diagnosis and correction, evidence abounds that progress is possible even though faltering, spotty, and unsatisfactory. Administrative action proceeds according to a principle not unlike that of quantum physics. It proceeds in fact in quanta of efforts, contingent upon dramatic events, public impatience, government prodding, and public health evidence. One conclusion is certain, namely, that progress in control is not uniform either in geography, in time, or in solution. Within this framework, however, with sufficiently eager intent, change does come about.

A striking illustration of this fact is apparent in the site selection problems associated with atomic power reactors. Almost from the beginning these issues demanded a prompt and ever-expanding marriage of meteorology, biology, and nuclear physics. In fact, interdisciplinary research and consultation arose out of the nature of the problem. The development of people increasingly familiar with the sciences and technologies of the broad areas involved was deliberately fostered by the Atomic Energy Commission and the Public Health Service. To make this possible, the exotic and dramatic features of nuclear fission were prerequisites to action. In a short time, however, basic data collection, development of safety criteria, continuing search for medical and epidemiologic evidence, and design and operating controls, moved

forward simultaneously, albeit unevenly. It is no reflection upon these advances to recognize that air pollution control techniques are not yet of sufficient efficiency or guaranteed continuity to permit power reactors to be located in densely populated centers.

Although reasonable success has been experienced with reduction of sootfall, the remaining list of contaminants is formidable. Their identification has been increasingly successful. The effect upon the human body again leaves great areas of unknowns. One may have some optimism in the fact that automobile exhaust is better understood and that activity is great on attempts to control it. Although the expenditures may still be too small on a national scale, it does reduce frustration somewhat to note that in the installations of oil companies in Los Angeles some $66 million has been spent for air pollution control equipment in the last 13 years.

If confessions are in order, it must be admitted that much remains to be done, from the air pollution standpoint, in the collection and disposal of urban wastes. With some exceptions, these operations, even in the newer plants, contribute to pollution of the air at least intermittently. Undoubtedly, the reduction of such discharges to a vanishing point entails expenditures which must be balanced against the benefits to be derived. As in all of these efforts, the socioeconomic equities are by no means insignificant.

Future technology is of course confronted with an even greater problem in adjusting the transport vehicles for man and freight so as to fall within the category of relatively pollution-free systems. The present trend in this adjustment is dominantly in the direction of adding devices to existing equipment and mechanisms in order to improve combustion and reduce contaminating materials. How soon will consideration be given to alternative sources of power? Some suggestions have already been made that battery-driven vehicles of improved design and efficiency might well displace the urban freight and mass passenger vehicles of common use. Does the strategy of air pollution abatement encompass a recognition of alternative or substitutive forms of energy for the more familiar and more objectionable sources now in use?

Is there also some antipollution rationale in congested urban areas for the transport of people en masse, rather than in individual cars? Can the forces of logic and economy, joined with the throttling of urban movement by the automobile, result in a major reduction of air pollution by mass transit alone? It does not require too much imagination to suggest that the traffic managers of Los Angeles, New York City, Washington, Baltimore, Chicago, and other urban areas should be parties to an air pollution conference. They can be militant contributors to either increased or reduced pollution, depending upon their solution to the whole traffic problem of highly urbanized areas. Whether the public remains the victim of its own decisions is contingent upon how informed it becomes as to the penalties involved.

SUMMARY

Air pollution is an increasing environmental evil, consequent upon the expanding urban-industrial society in which we live. Its components are complex. Its biological effects are subtle and difficult to assess, whether on a short- or long-term basis. While these effects on man and on animal and plant life are under scrutiny, public action cannot remain quiescent. It must move forward toward cleaner air with reason and with economic equilibrium.

For such action to be both intelligent and successful, it must be predicated upon continuing accumulation of basic data as to air contamination. It must measure geographic, climatic, and temporal changes. These must be related to pathologic effects in man and plant. Their impact on material things must be evaluated.

With such information increasingly at hand, control becomes easier to justify and to initiate. Regulatory decisions require research into industrial and domestic practices in order to disclose those adjustments in method and machinery which will alleviate pollution.

Examples of such possibilities are provided in the history of the atomic energy industry, in smoke prevention, in oil refinery practice, and to some degree, in the handling of urban wastes.

Major contributions for the future are latent in developing pollution-free transport and power production. Will these result from adjustments of orthodox energy producers or from the development of new techniques?

The restoration of some reasonable measure of purity in the air will require the forces of many disciplines, chemistry, biology, physics, engineering, to name a few. Above all, the backing of public opinion is perhaps a major essential. But public opinion should be purchased at the price of increased knowledge and judgment.

DISCUSSION

Fred W. Thomas. I should like to add one point to the paper I read for Dr. Gartrell. The need for closer coordination of public and private efforts in attaining an objective recalled a situation that seems to have a rather close analogy. In the Tennessee Valley Authority we have two staff groups concerned with the health and welfare of workers on the job: the safety engineers, who are primarily concerned with prevention of traumatic injuries, and the industrial hygienists, who are primarily concerned with conditions that might lead to acute or chronic systemic health effects from exposure to gases, dust, heat, and so forth. After several years of observing and working with these groups, I am convinced that the two goals are almost inseparable. Each group is needed to support the other; the industrial hygienists can strengthen the safety engineers and the safety engineers can strengthen the industrial hygienists, and in many instances responsibilities overlap to such an extent that it is impossible to say that this is a safety problem or that it is an industrial hygiene problem. And so we have come to recognize that, in order to accomplish the ultimate objective, which is protection of the worker, the two groups have to work together.

In the same way, I wonder whether the public and private efforts to abate air pollution which have been mentioned here could not agree upon a common objective and then establish logical and reasonable steps toward attaining this objective. Then some of the differences which are evident now might gradually disappear.

Isador W. Mendelsohn. With all the fine work that has been accomplished in Los Angeles, can Mr. Chass say that in the near future Los Angeles will be free of smog?

Chass. We firmly believe that smog as we now know it will be eliminated once motor vehicle emissions are under control. I wish I could predict the day when all of the vehicles on our streets and highways will be properly controlled. But there is no doubt at all in my mind that smog will be with us in Los Angeles as long as the motor vehicle continues to operate uncontrolled.

Mendelsohn. Dr. Brandt's idea for getting better cooperation in air pollution control between regulatory bodies and industry by including industrial representation on regulatory bodies is basically correct and truly American. A longstanding regulatory agency exemplifying this cooperation is the Public Health Service Committee on Drinking-Water Standards on Interstate Common Carriers, which dates back to 1921. In this case, industry affected in any respect whatsoever by the regulations has been represented from the beginning. The Public Health Service is required by the Interstate Quarantine Regulations to safeguard public health by making sure that safe water is provided to the public on all carriers.

In 1921, the Service was concerned with railroads and steamships. Since that time, busses and airplanes have become important, too. In carrying out a responsibility which affected not only all the carriers but also many hundreds of city water supply systems and all State boards of health, it was considered necessary to have unanimous opinion for unanimous action. So the committee included representatives of all the regulatory bodies concerned and all industries concerned. This committee has functioned satisfactorily since its inception, to my knowledge.

Smith. I have an addition to make to my prepared paper. It is based on something which Mr. Robert McCormick mentioned in a recent presentation too late to include. In the studies which the Public Health Service people conducted in Nashville, they found it necessary to introduce a 4-hour half life in order to make the sulfur dioxide (SO_2) figures come out properly as far as the concentration predictions were concerned. Now, this 4-hour half life is of considerable significance if you're going to talk about distances of 20 or 50 miles. The fact that the data are off by a factor of 2 could mean either that the meteorological parameters are inaccurate or that the SO_2 is being depleted at a significant rate. So we feel that one of the big problems in dealing with the extended distances situation is to assure ourselves that our studies are being done with tracers whose life in the atmosphere is definitely predictable.

In regard to this, I am personally interested in the most serious lack we have at the present time, which is in our knowledge of the cleansing processes in the atmosphere. The work that is being done on this is, I think, very good, but it is progressing slowly. We have relatively few results at the present time, and certainly this matter of cleansing the atmosphere is an area in which very considerable expansion of our knowledge is needed.

Walter L. Brytczuk. Mr. Smith, has this 4-hour half life for SO_2 been found in other studies besides the Nashville survey you mentioned? Does

tioned. But beyond that, there is considerable evidence that the SO_2 in the atmosphere certainly is depleted at interestingly rapid rates. This is one of my reasons for being so concerned about the interdisciplinary aspects of the problem. No one trained solely as a meteorologist is going to answer this question properly. Clearly we need meteorologists and chemists (probably physical chemists), all those interested in small particles, in order to solve problems of this kind.

Brytczuk. That has also been our experience in New Jersey. Our smoke usually disperses rapidly, but the rate of SO_2 dispersion does vary here, depending on the inversion conditions. We have had problems with effluents which hung around in Carteret for a considerable length of time. Dr. Pack reported that our knowledge of the behavior of pollutants released from high stacks is limited. Perhaps our experience will be of some value. Dr. Smith mentioned that he did some flying before the days of high powerhouse stacks and before the days of jets. I understand that pilots used to follow smoke streams to the Newark airport. They could see our smoke for 20 or 30 miles if the wind was in the right direction; it made a very nice guide to come in by. Well, during the same period, we had a mobile smoke monitoring unit riding around at points where our smoke stream was hitting the ground, and we have considerable data, collected over a number of years, on the SO_2 concentration at the point of impact. This point varies, of course, depending on wind and weather conditions, anywhere from 2 to 15 miles away from our stack.

Gordon C. Harrold. The accent on a study of considerations in relation to air pollution brings up several pertinent points. Some of us like the smell of burning leaves in the fall. This may not be significant in California, but it only emphasizes the differences between most of California and the rest of the United States. Some people like the smell of cooking corned beef and cabbage, and some do not. What I want to point out is that air pollution control can be not only uneconomic but also somewhat distasteful to a large part of the populace.

It is true that some communities do not want industry. Most progressive groups do want industry, necessary, it may in some instances cost more than a given industry can afford in any one location, at least for the degree of cleanliness demanded by regulations in that location. I want it to be clearly understood that I am speaking about esthetically clean air, not about air which will injure health or interfere with the reasonable enjoyment of the individual's private property. Real health and nuisance hazards should never be permitted.

As an independent consultant, I advise communities and neighborhood groups, as well as industry, and I wholeheartedly endorse Dr. Brandt's remarks. His statement that industry in most instances is anxious to be a good citizen is particularly noteworthy. In most areas, there is a lack of understanding between the regulatory agencies and industry, and in other areas—Detroit and Toledo are examples—there's a cooperative attitude which in a quiet way gets the necessary work done without the fanfare attending some other area developments.

Another item related to this topic is provided by the comments on municipal incineration. As part of my consulting work with a midwestern community which had been considering this problem for a number of years, we visited just last week one of the best of the New York City incinerators, which was far from satisfactory. This trip was attended by both political and industrial leaders of the community, and was paid for by industry. This cooperative effort led to the belief that a proper landfill method would be the most desirable waste disposal method until better types of disposal are developed.

Our experience indicates that industry, when given time to perfect new processes, will thereafter proceed more rapidly toward some air pollution abatement than many governmental agencies charged with plant operations. Finally, the Midwest is not blessed with the sunshine of California. It is also not cursed with many of that State's problems. We do not believe that we need the same degree of control or amount of expenditure for clean air that might be needed in the Far West.

DeYarman Wallace. Mr. Chass lists in his table 3 the cost of basic control equipment. Is the off-site cost included? Or is this a figure quoted by the equipment manufacturer? The off-site cost figure

the table.

Chass. The procedures in effect require that the applicant file with the district not only his plans and specifications but also an estimate of the cost of both the basic and the control equipment. When the district engineer makes his final engineering inspection of the equipment in operation, a check is made to determine these prices or costs. At no time is the equipment manufacturer or supplier contacted. To our knowledge, these figures include what I believe you call off-site costs. They do not include basic research or development costs. But they do cover the outside costs, including whatever planning went into the installation.

James L. Dallas. I agree with Dr. Brandt that full cooperation and understanding between industry and regulatory agencies are very, very important. We in the Massachusetts State Health Department closely cooperate with Bethlehem Steel in Quincy. I hope, however, that Dr. Brandt does not feel that there is a universal lack of cooperation and I hope that he also recognizes that there is not a universality of conflict throughout the States. In some areas, conflict may exist. My question to Dr. Brandt is intended to be respectful. Do you propose to grant reciprocity to governmental regulatory personnel? Do you propose that they be granted full voting-power representation on the boards of directors of air-pollution-producing industries, as urged for industry on regulatory boards?

Brandt. In response to your first comment, I apparently conveyed the impression—and Dr. Wolman also seemed to think I did—that nowhere in the country do we have this sort of cooperation. Many nongovernmental people are represented in many of the governmental agencies. It is not at all uncommon. My only point is that there are many places where such cooperation does not exist and I personally should like to see it in many more places. As for your specific question, I should like to answer it, but adequate time is not available to do so in a clear and meaningful fashion. Incidentally, I don't happen to be on the board of directors of any company. I wish I were.

John G. Mingle. Table 1 of Mr. Chass' presentation shows that 150 tons per day of oxides of nitrogen are prevented from entering the Los Angeles atmosphere and, if I interpret correctly, this happens because of the burning of natural gas as fuel

Chass. The answer is in the second table. The combustion of natural gas does not generate as much oxides of nitrogen as the combustion of fuel oil.

E. Wendell Hewson. My question is addressed to Mr. Hovey, who read Mr. Rihm's paper. Shouldn't we use meteorology more widely in the management of our air resources? In the first place, industrialization seems to be increasing exponentially, so we probably shall be having much greater problems in 5, 10, or 15 years from now. Second, contaminants collected at the source are expensive to collect and also to dispose of. Third, the atmosphere has a terrific range of variation in its capacity to absorb contaminants without nuisance or harm. For example, the figure of 1,000 to 1, or even 10,000 to 1, has been used frequently. On one particular day 1,000 or 10,000 times as much contamination could be safely accepted by the atmosphere as on another day with less favorable conditions. So should we not design the plants now on the drawing boards or to be on the drawing boards next year in order to permit us to make use of this widely varying facility of the atmosphere to absorb contaminants?

Harry Hovey, Jr. In our rules and regulations in New York State we do recommend making allowance for this in any new installations. I agree with the rest of your statement. I think other people here probably would, too. As far as the meteorological parameters you mentioned are concerned, it's still up to the meteorologist to give us the information on how much the atmosphere can dilute.

Sidney Marlow. One of the points made by Dr. Brandt was the tendency not to report failures and to look only at the successes, but I think most will agree that we learn more from failures than from successes. Mr. Chass, in view of your statement that the district has made mistakes in air pollution control regulations, can you mention some of its important mistakes and how other regulatory agencies can learn from these mistakes?

Chass. During the early years of the district, several control installations were approved before sufficient data and knowledge had been accumulated. For example, a scrubber was approved for a gray iron cupola, deodorizer equipment for a rendering plant, and a packed tower for an asphalt-roofing plant. Enough knowledge has been accumulated by the district so that such mistakes are

so that other control agencies might benefit. We have, to the best of our ability, published the successes. At the present time, we are preparing an engineering manual on the subject of air pollution control, and we hope to include some of those failures as well as the successes.

Smith. Mr. Chass, you said that, in your opinion, each community must decide upon its standards and then proceed to enforce them. And I got the distinct impression that you were excluding from such "communities" the larger scale governmental agencies, particularly the Federal Government. Isn't it obvious that your definition of "community" must become far larger than the one you implied when you consider that Baltimore affects Philadelphia, which affects Newark, which affects New York, and so on up the coast? In other words, I go back to my own discussion of scale. Some problems are exceedingly local. Your cigarette might bother me at this distance. Other problems are obviously international and worldwide in scale.

Chass. For want of a better term, I used the word "community." I did not want to imply that I defined it as a very small area. In some cases, a community can be a small city; in other cases, a large city. Sometimes it is a county, and it can be a State. Also, it can be a multistate area. Under no circumstances do I want to advocate the rules in effect in Los Angeles for other communities, because the problems would be different, the meteorology would be different, and the demand of the public would be different.

The board of directors of the Bay Area Air Pollution Control District, of San Francisco, Calif., has taken a position on each of the subjects that are before us at this conference. So far as this panel (F) is concerned, we have two major points.

No. 1. The Federal Government should finance the collection of practical and technical information about the specific installations of control equipment and methods on polluting operations being installed in communities, as they have done in the past in some instances. The Federal Government should also finance the dissemination of such practical and technical information to operators, control agencies, and other interested parties, using anonymous designations where necessary, as is done in medical case history registers and publications. The information should cover installations that are both successful and unsuccessful, as judged by the emissions and the effects. The information should also cover the capital and operating costs in terms of dollars and percentage of plant investment and percentage of gross operating costs, to the extent that these figures can be obtained.

No. 2. The various groups that do meteorological work, especially in climatology, should be encouraged to provide more information for use by air pollution control engineering and enforcement specialists, who can use it to trace the paths of pollutants and to design suitable control installations, and to develop suitable legal regulatory measures for their community.

CONCLUDING REMARKS

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It is my assignment in the space of 10 minutes to summarize these fine papers, to recognize some of the floor comments, and to add perhaps a few thoughts of my own. I give reassurance to those participating in the open discussion, which we have just had, that much more recognition will be given to summarizing these thoughts in our panel report tomorrow than I can give at this time. I am sure you will understand my intent when I say that the opinions expressed by the speakers which I will now summarize are not necessarily my own.

Our panel chairman pointed out three broad alternatives for use in decreasing the amounts of air contaminants that reach people and their property. These are: (1) process and raw material modification; (2) optimizing atmospheric dispersion by judicious selection of stack parameters and recognizing their interrelation with the terrain and climatological regime; and (3) use of equipment to collect undesirable dusts and gases. It is noted that these alternatives are frequently complex and almost always costly. Dr. First cautions that not all control measures can be justified economically on the basis of our present knowledge of the harmfulness of certain air pollutants. He adds that control for esthetic reasons alone is not necessarily invalid. However, he stresses that our search for economically acceptable means to bring this control about has not been fully successful.

As mentioned, one of the control methods is meteorological dispersion. Mr. Smith gave an excellent review of what is known today about this subject and the extent to which we may depend upon it to prevent air pollution from occurring. He points out that our knowledge of dispersion from single stacks located in flat terrain is well in hand and that the advent of the high-speed computer has made multiple-stack source analysis possible. I can personally reaffirm this, since my company has had gratifying results with computer analysis since 1956. The following problems were highlighted as requiring further clarification: (1) dispersion characteristics over great distances; (2) deposition of solids on the ground; and (3) relationship of average- to short-term concentrations. It is gratifying to hear cited the great research effort that is giving attention to these problems. Lastly, Mr. Smith drew attention to the problem of analyzing the air pollution potential of a large city. It appears from studies in Nashville and Louisville that this seemingly very complex problem holds promise of being simplified and solved.

Mr. Pack, in reviewing this paper, brought out several significant points. I will mention two. One is the previously cited problem on the relationship of average- to short-term peak concentrations. I agree wholeheartedly with both gentlemen that a better physical explanation of this phenomenon is desired. A practical application of this knowledge would be its use to improve our ability to anticipate, and hence minimize, the frequency and duration of occurrence, for example, of odors. Note was also made that knowledge is lacking on the significant matter of the relative importance of the effect of these transitory higher concentrations on man, plants, and material as compared to the lower long-term concentrations. Another problem cited was the need for greater knowledge on the mechanics of how, and the extent to which, the atmosphere cleanses itself. This presents intriguing possibilities for speculation should weather-modifying techniques become sufficiently sophisticated to make

phere. The remarks of both Mr. Smith and Mr. Pack give reassurance that the meteorologist is a strong member of the team and that he is actively enlarging our understanding of the problem.

Mr. Chass provided a fine résumé of the accomplishments of the Los Angeles control program in terms of tons of reductions realized and the costs, and in pointing out that their stringent regulations encompass all segments of their population's activities. A significant item is the cost. It is a point stressed by many of our panel speakers. Mr. Chass stated that, in the Los Angeles County Air Pollution Control District, on the average, the cost of control equipment is about 25 percent of the cost of the basic production equipment, and that individual installations may range up to several times the cost of the production equipment itself. Mr. Chass summarized that technical know-how and the actual control devices are now available to control almost any air pollution from stationary sources and that it is up to the community to decide what degree of clean air it wants.

In Mr. Rihm's discussion of this paper he stressed practicality in economics and the need at times to make compromise. He cited, for example, that while an incinerator may be less perfect than a landfill for municipal garbage disposal, such land is not always available. We face the prospect of having to haul this material 50 or 100 miles away from a metropolitan complex and with no assurance that our country brothers will want it either. Mr. Rihm added that it is not so much the tons of material kept out of the atmosphere as whether the contaminants present are at or below satisfactory levels. I must add that this is an eminently sensible and practical observation.

Dr. Brandt stressed the theme that to coordinate public and private control efforts better would require an improvement in the communications between "regulator and regulated." To enhance this communication, he stressed the need to increase greatly the number of nongovernment participants on committees, boards, and commissions. He stressed the need for greater communication on equipment performance. He pointed out that it is human nature to publicize successful control equipment applications and refrain from announcing failures. This behavior frequently leads to the assumption by control officials and others that a given control device may have universal application. He a concept.

Dr. Gartrell in discussing this paper raised the question of whether coordination between all interested parties had not reached the point where it takes up a disproportionate amount of time which could be put to better use in finding solutions. He also pointed out that, while persuasion and volunteer actions by the "offender" is a preferred method, compulsion by control agencies will at times be necessary to effect results. On this second point, when it is put in these broad terms, I think Dr. Gartrell is correct. He feels that ambient air quality standards have a certain advantage because they afford greater flexibility. However, despite the limitations and objections of emission standards, he feels these will continue to have wide use. If the latter is true, it is my strong hope that a more scientific basis and real justification, based on relating the emissions to effects on people and property, will be incorporated. To this end, even stack emission standards could be made more flexible, to reflect the control requirements which ambient air measurements indicate are needed. From a practical viewpoint, these concepts of stack emission standards and ambient air standards are not incompatible and in fact are interrelated.

Our last speaker, Dr. Wolman, stressed the parallel between the United States and Europe, which is somewhat ahead of us in density of population and industry. He pointed out that the lessons of public health history indicate that action can precede complete scientific verification. He stressed, however, that if action is to be intelligent and successful, facts are needed. With these, a more convincing control program will come forth. Other key points were that government edict will not suffice; that a broad range of disciplines is needed to further our knowledge; and that major contributions for the future are latent in the development of pollution-free transport and power production.[1]

In conclusion, we see a great range of ideas, in some cases, a divergence of opinion. It is for this very reason, as I see it, that we must constantly be seeking a balance in the degree of control measures undertaken. The economics cannot be reasonably ignored—it is too significantly large. For instance,

[1] At this point, the oral presentation summarized the questions, answers, and statements originating from the open discussion. These are deleted herein since they are reproduced in complete form at another place in the Conference Proceedings.

tion equipment. To obtain what is admittedly a very high spot estimate of what a comparable control program would cost nationwide, let us assume that the 25 percent applies to total plant assets. At the beginning of this year the assets of all United States manufacturing corporations totaled about $300 billion. Twenty-five percent of this would represent about $75 billion for air pollution control in the United States. Now investment in new manufacturing facilities for 1962 is estimated at $37 billion. Thus, the $75 billion for air pollution control would represent the amount spent in the entire United States for the next 2 years to expand the production of goods. I might add that the annual operating cost of this equipment might involve an additional estimated $15 billion per year. This is about equal to the increase in the gross national product for a year. I merely point this out to show that great responsibility and judgment must be exercised in this field and that a real crash of human health represents the hard core of control needs and, when the limits are clear, the cost for this is of sufficient justification in itself. However, in scaling down from this, reductions for other reasons must seek some justification if we are to be guided by the precepts of logic and our scientific training. The justification may be economic loss, but let us have some real knowledge of what it is. The justification may be the nuisance of odors or dust deposit or the pure esthetics of a crystal-clear atmosphere. I believe in any of these cases that we must not be satisfied to be arbitrary, and that we must strive to justify what it is that the control effort will accomplish, and establish its worth in terms of economic and social benefits. Above all, we must be exceedingly honest with ourselves. If indeed the preservation of esthetics is the valid reason for control, it should be recognized as such by the public and with full knowledge of the ultimate cost and benefits.

Panel G

APPLYING OUR LEGISLATIVE AND REGULATORY KNOW-HOW

Know-How to Air Pollution Control

Chairman: Erwin E. Schulze
Co-Chairman: Sidney Edelman
Reporter: Charles W. Gruber

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We are told, upon what authority I do not know, that air pollution first became a problem for organized society in the 14th century. I take it that those who preface their remarks with this observation intend (depending upon the side of the fence they occupy) to suggest thereby either that air pollution is an age-old problem and hence not new or menacing, or that man has been polluting the atmosphere for six centuries and it's time that we did something about it. My intent is neither of these; it is simply (in view of the theme of this panel) to point out that if air pollution has been around a long time, the law has been around even longer. It is true that we hear a great deal more about air pollution these days than we did 4 years ago—or even a year ago; and that 10 years ago only a handful of States had a law dealing with the subject while today more than a majority have such laws. You have seen the same thing happen in your local community. But this does not mean that we are developing a whole new body of law. On the contrary, legal principles remain relatively unchanged (or should) and only the area of application is new. Even here it is more likely that what is new is the emphasis on the subject. As in all things, progress in the law is by evolution, and we are witnessing today a reevaluation by society of the social advantage or disadvantage of air pollution. You can be sure that this reevaluation, reflected as it is in the attitudes and actions of our duly elected representatives, will have a comparable reflection in the judgments and opinions of our courts.

The question before our panel today is quite pragmatic. It is this: Do we have the legal weapons with which to combat air pollution; and, if so, how should we use them? On this score I think you will find that the answer to the first half of the question is "yes" and to the second half that that division of government closest to the people which can deal with the problem effectively should have the primary responsibility. These conclusions should not surprise you, but I think you will find the trip there most interesting.

Do we then have serious legal problems facing us in the air pollution field? This is a perplexing question because, as with so many problems, the answer is dependent upon man and not the law. In our rush to get into the field, to be doing something about air pollution, we must take care not to brush aside basic principles of freedom of person and property and of adherence to due process of law. In our zealousness to purify the air we breathe, we must try not to overstate our case in order to gain support or be too quick to place those who oppose us in the category of enemy. These problems are not new, nor are they unique to the field of air pollution. They are problems which we face on all sides and have faced since the days of early Rome.

As an example of what I mean, we have a law on the books in Illinois, and copied in a number of other jurisdictions, which contains unique limitations on emissions into the atmosphere. To exceed these limitations is to commit a crime. These standards "bear no relation whatever to the public health, welfare, safety, or comfort." This is not my opinion but the reluctant admission under oath of the author of the limitations. There is no reason whatever why that law could not have been drafted properly so as to give due consideration to accepted practices and the confirmed advances of modern technology. Instead we have a law which is basically unenforceable and undoubtedly invalid. Has society benefited? I think not.

that responsibility of leadership is being discharged

instead we concentrate on that common goal.

THE MECHANICS OF LEGISLATIVE AND REGULATORY ACTION[1]

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It should be encouraging to people concerned with community air contamination that much of this National Conference is concerned with applying existing know-how to the solution of the problem at hand. The people of this Nation are conditioned to expect that serious problems will be solved quickly. The fact that our citizens take almost for granted the monumental advances in space, atomic energy, communications, and medicine is evidence of the high regard in which the American people hold their society.

The plain fact is that government and industry have not acted with reasonable celerity in many fields in which the public health and safety are involved. Our people are still being used as experimental animals by drug and cosmetic manufacturers. Rivers and beaches are threatened by pollution from industrial wastes and sewage. People with serious illnesses are still being treated with useless preparations by "doctors" with degrees from nonexistent medical schools. Of special concern to us is the fact that until recent years urban residents have been subjected to uncontrolled air contamination. For nearly two decades we have heard the pleas and arguments of those who advocate self-regulation. We have been warned against hasty action and advised to conduct thorough research before imposing regulations. Our experience over this period, however, has demonstrated that regulations should be adopted as soon as possible, and that effective regulation does not require perfect knowledge.

It would be beyond the scope of this paper to consider at length the various specific statutes and regulations which have been adopted, or to evaluate their effectiveness. The principles which we shall discuss, however, are of reasonably general application. In the main, they are principles which have been tested in practice and found to be satisfactory.

A. THE ROLE OF RESEARCH

One issue usually arises in any discussion of adopting regulations or legislation. That issue is whether or not we possess enough scientific information upon which to base regulatory action. The answer is that we do.

At this late stage in the development of the air pollution problem, arguments are still being made that regulations should await the fixing of community air standards and contentions are presented that even these standards should not be set until further medical research has been performed.

It has been well known for centuries, of course, that air pollution can be injurious. No further research is necessary to demonstrate that dust and fumes can kill crops or that smoke emissions can cast a pall of grime and gloom about great cities. The effects of other types of emissions, many of which are not even visible, are less obvious. Typical examples are oxides of nitrogen, sulfur oxides, carbon monoxide, and hydrocarbons.

In the late 1940's, Los Angeles County was faced with the very serious question of whether to attempt to single out and control specific sources of pollution, or to attack each and every source. The final decision was that we could not wait for perfect knowledge, but had to move immediately to abate all emissions. The Air Pollution Control District

[1] Read by Robert M. Barsky.

was frequently criticized for attempting to control "harmless" emissions.

Fifteen years later we can observe real and effective control over all sources of air contamination for which control methods exist. The journey has been a difficult one. The experience has shown, however, that an effective air pollution program need not await the culmination of research projects. Equally important is the fact that our strong program did not cause even an apparent ripple in the tide of economic progress. It is also of considerable interest that not one of our rules, new and untried as they were, was successfully challenged in the courts.

No one will deny that scientific research in the field of air pollution and its effects should be expanded many times. The point under consideration here, however, is whether or not the adoption of regulations should be delayed until more research has been done. The conclusion to be drawn is that strong and effective rules can be adopted now.

B. *LEGAL FOUNDATION FOR REGULATION*

Much of the legal groundwork for regulation of air contamination has already been laid. The following discussion will outline the basic legal question which any rule must answer satisfactorily.[1]

1. *Does the Agency Have Power to Adopt the Regulation?*

As we shall see, almost all regulation of air pollution is founded upon the "police power" of government. The term "police power" is very broad and does not lend itself to any practical definition. It is a dynamic term subject to change and evolution as a commonwealth develops politically, economically, and socially.

Miller v. *Board of Public Works,* 195 Cal. 477, 234 Pac. 381. It is a power of sovereignty inherent in a *State* and possessed by each of them. The police power of a municipality is never inherent but is a power received by delegation from a higher source through a constitutional, statutory, or charter provision. *Leighton* v. *Minneapolis,* 16 Fed. Supp. 101; *Denninger* v. *Pomona Recorder's Court,* 145 Cal. 629, 79 Pac. 360; *Commonwealth* v. *Plaisted,* 148 Mass. 375. The mode of delegation of the power ordinarily is not important, if it is in fact delegated. *Wichita Falls* v. *Continental Oil Co.,* 117 Tex. Com. App. 256; 1 S.W. 2d 596; *People* v. *Chicago,* 413 Ill. 83, 108 N.E. 2d 16.

The police power delegated to cities and counties is not all-embracing, however, in that the State may take such power unto itself by direct enactment or by occupying the field. *In re Iverson,* 199 Cal. 582, 250 Pac. 681.

It is the general rule that there cannot be a conflict between local ordinances and the State law, unless the State law itself allows the difference. *Ex Parte Hoffman,* 155 Cal. 114, 99 Pac. 517; *State* v. *Dannenberg,* 150 N.C. 799, 63 S.E. 946. Under this rule an ordinance ordinarily cannot permit that which the statute forbids, or prohibit that which a statute in effect directs to be permitted. Ordinances may ordinarily add additional restrictions to those established by State law. *Borok* v. *Birmingham,* 191 Ala. 75, 67, So. 389; *Sternall* v. *Strand,* 76 Cal. App. 2d 432, 172 Pac. 2d 921. In some States, ordinances which cover the same acts as the State statutes are invalid. The most common theory for so holding is that to allow both to stand would result in double jeopardy. *State* v. *Dannenberg,* 150 N.C. 799, 63 S.E. 946.

The validity of an ordinance, statute, or rule regulating the emission of smoke or fumes does not depend upon whether or not the emission is a "nuisance" at common law. The validity depends entirely upon whether or not the law comes within the constitutional limitations and, as in the case of a local agency, whether or not it has power to pass such a law.

A leading case on the subject is the California case of *In re Junqua,* 10 Cal. App. 602, 605, 103 Pac. 159. In this case the petitioner sought a discharge on a writ of habeas corpus to test the validity of a Sacramento ordinance which provided:

> It shall be unlawful for any person, firm or corporation to permit any soot to escape from the smokestack or from the chimney of any furnace within the City of Sacramento in which distillate or crude oil is consumed as fuel.

The petitioner claimed that the ordinance was unconstitutional and void on its face, as under the ordinance it made no difference how little soot was emitted. The court stated:

> That the police power is an inherent attribute of every state or commonwealth in the Union is a proposition which will be readily conceded. It is not only a power which inheres in the sovereignty of the states, but is a power the exercise of which by the states is indispensably essential to the health, peace, comfort and welfare generally of the inhabitants thereof. . . .
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> This power embraces the right to regulate any class of business, the operation of which, unless regulated, may in the judgment of the appropriate local authority, interfere with the rights of others, for, as is said in *Dobbins* v. *City*

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[1] For a more extensive discussion, see: Kennedy, The Legal Aspects of Air Pollution Control, 27 So. Cal. L.R. 373.

of Los Angeles, 139 Cal. 179, 96 Am. St. Rep. 95, 72 Pac. 970, "all property is subject to the police power." In other words, the proposition cannot be maintained that the exercise of this power is confined to the regulation only of such interferences with the public welfare and comfort as come strictly within the common law definition of a "nuisance."

See also: *Buffalo* v. *George P. Ray Manufacturing Company,* 124 N.Y. 931, Ann. Cas. 1918 B, 174.

Within the limitations noted, and within constitutional principles of due process and equal protection of the laws, the power of a city, county, or district to regulate air contamination is essentially complete.

Without a doubt it is within the competence of a State legislature to confer upon municipalities power to enact ordinances to protect against atmospheric contamination or pollution, such as smoke ordinances.

7 McQuillin, Municipal Corporations (3d Ed.), p. 469, 470.

2. *Does the Emission Constitute a Nuisance?*

It should be noted that most of our early law and that of the English cases dealt with air contamination as a part of the field of tort law commonly referred to as "Nuisance." Smoke was considered to be a nuisance at common law, but it was not a nuisance per se. That is, in each individual case it had to be proved that the smoke was in fact injurious or offensive to the senses. In the case of a public nuisance it had to be proved that a large number of persons were affected.

It is now a well-settled principle that although at common law smoke and other contaminants were not considered to be a nuisance per se, the legislature can declare air contaminants to be a public nuisance and the courts will not invalidate such legislative acts provided that the legislative declaration is reasonably clear and certain. Indeed, whatever pollutes the atmosphere, whether it is smoke, dust, chemicals, or gas, depriving inhabitants of pure, uncontaminated, and inoffensive air constitutes a public nuisance in fact, if not per se. *State* v. *Luce,* 9 Houst. (Del.) 396, 32 Atl. 1076; *Department of Health* v. *Ebling Brewing Co.,* 38 Misc. 537, 78 N.Y.S. 11.

In the case of *State* v. *Tower,* 185 Mo. 79, 68 L.R.A. 402, 84 S.W. 10, it was held that the State under its police power could declare smoke a nuisance per se, even though not a nuisance per se or a nuisance at common law, and strong support for the rule can be found in subsequent cases. *Northwestern Laundry* v. *Des Moines,* 239 U.S. 486, 36 S. Ct. 206, 60 L. Ed. 396; *State* v. *Chicago, M. & St. P. Ry. Co.,* 114 Minn. 122, 130 N.W. 545.

It is well established that impairment of health need not be shown for an emission to constitute a nuisance. Discomfort, inconvenience, and annoyance to the public are sufficient to render the emission of fumes a nuisance, and also to permit its abatement by statute. 39 Am. Jur. 337, Note 19, Section 54; *Moses* v. *United States,* 16 App. D.C. 428, 50 L.R.A. 532; *Judson* v. *Los Angeles Suburban Gas Co.,* 157 Cal. 168, 106 Pac. 581; *Dauberman* v. *Grant,* 198 Cal. 586, 48 A.L.R. 1244, 246 Pac. 319; *State ex rel. Krittenbrink* v. *Withnell,* 91 Nebr. 101, 135 N.W. 376, 40 L.R.A. (N.S.) 898.

3. *Is the Rule Certain? (Due Process)*

It is well recognized that any law must be clear, precise, definite, and certain in all its terms, and that one which is vague to such an extent that its meaning cannot be ascertained is invalid. The underlying basis for this rule is the necessity of notice to those affected by the enactment.

In 1955 the U.S. Supreme Court (351 U.S. 990, 100 L. Ed. 1503) dismissed an appeal from the decision handed down by the Appellate Department, Superior Court, Los Angeles, involving four separate cases each of which involved one or more convictions of smog violation. *People* v. *Plywood Manufacturers of Calif.; People* v. *Shell Oil Co.; People* v. *Union Oil Co.; People* v. *Southern Calif. Edison Co.* (all reported in 137 C.A. 2d Supp. 759; 291 P. 2d 587).

The defendants were convicted of violating section 24242 of the Health and Safety Code. Section 24242 provides:

A person shall not discharge into the atmosphere from any single source of emission whatsoever any air contaminant for a period or periods aggregating more than three minutes in any one hour which is:

(*a*) As dark or darker in shade as that designated as No. 2 on the Ringelmann Chart, as published by the United States Bureau of Mines, or

(*b*) Of such opacity as to obscure an observer's view to a degree equal to or greater than does smoke described in subsection (*a*) of this section.

Directly involved was subdivision (*b*) relative to opacity of emission. The Appellate Department, after recalling its prior decision in *People* v. *International Steel Corp.* (1951), 102 Cal. App. 2d Supp. 935, 226 P. 2d 587, that the standard made use of in subsection (*a*) is sufficiently definite to satisfy due process, went on to say:

> Subdivision (*a*) only begins to solve the problem of the discharge of contaminants into the air; it does not touch smoke and other substances too light in shade to come up to Ringelmann No. 2. They may be so substantial in nature, however, that they make it impossible to see an object on the other side. We have all seen very white smoke that shut out the view completely. Again they may obscure the view to a lesser degree than totality . . . .
>
> We may, therefore, express the test of subdivision (*b*) in simple terms; it condemns smoke or any other contaminant that is at least as hard to see through as is smoke which is as dark or darker than Ringelmann No. 2. There is nothing mystic or incomprehensible about such a statement.

The court in upholding the validity of subsection (*b*) of the statute dismissed the contention made by appellants that section 24242 was unconstitutional for uncertainty, under the theory that an ordinary person having no special training will not be able to tell whether or not certain smoke is as dark as Ringelmann No. 2, by stating:

> A statute is invalid if its terms leave that which it attempts to control shrouded in uncertainty, but a statute which declares an act, identified with certainty, to be unlawful is not rendered unconstitutional because the act, as a fact, may not be readily identifiable by the common man as that forbidden by the statute.

4. *Is the Rule Reasonable?*

Any ordinance or statute under the police power must be reasonable, and for that reason must regulate or forbid something which is or could be considered detrimental to the public peace, health, safety, morals, or general welfare. If any set of facts may be supposed as to which a law or ordinance is reasonable, or if reasonable minds may differ on the question, the enactment will be sustained. *Matter of Miller* (1912), 162 Cal. 687; *Clemons* v. *City of Los Angeles* (1950), 36 Cal. 2d 95, 98–99, 222 P. 2d 439; *Miller* v. *Board of Public Works,* 195 Cal. 477, 488–490, 234 P. 2d 381. If the ordinance or statute passes this test, a naked violation of the ordinance is all that need be shown.

The legislature has a wide discretion in determining what is a nuisance and what is not, and what may be regulated under the police power. In doubtful cases, the determination of the question by the legislative body is conclusive. The courts will not interfere unless the law results in needless oppression, and will not question the wisdom of the legislation. The courts are not limited to the face of the law itself. They may look behind the law and determine from competent extrinsic evidence whether or not the law is reasonable. *Moses* v. *United States,* 16 App. D.C. 428; *Bradley* v. D· *trict of Columbia,* 20 App. D.C. 169; *Stat Tower,* 185 Mo. 79; 84 S.W. 10 (1904), *Cinci-* v. *Burkhardt,* 30 Ohio Cir. Ct. Rep. 350, Ann. 1918 B. 174 (1908).

In the case of *Moses* v. *United States, supra,* the court said:

> The policy of adopting a regulation to meet the conditions is a matter purely and exclusively within the province of the legislative department. The judiciary can only interfere with the exercise of the power where it is manifest that the regulation has no real or substantial relation to the object within the police power, and constitutes a palpable invasion of private rights.

It can be seen that what is *reasonable* depends upon the circumstances. No hard-and-fast rule can be established for all cases. It has been urged that legislation regulating the use of bituminous coal is unreasonable, especially in a district where soft coal is produced in large quantities and where such coal is universally used for fuel. It is argued that to enforce a law of this character would require industry to use expensive anthracite or other smokeless fuel, causing great hardship, and perhaps, driving many plants from the city. This contention was rejected by the Supreme Court of Illinois in the case of *Harmon* v. *Chicago,* 110 Ill. 400, 51 Am. Rep. 698, as follows:

> It may be that some, and perhaps, very great inconvenience would be experienced by a rigid enforcement of the provisions of this ordinance. How that may be this court cannot know. What powers the city council may exercise under the general law or under its police powers is a question of law to be determined by the courts; but when the city council will exercise the powers with which it is clothed rests in its legislative discretion, and the consequences that may flow from the enforcement of ordinances enacted within the powers conferred rest alone upon the body enacting them, and with which the courts have no concern.

In the case of *City of Brooklyn* v. *Nassau Electric R. Co.,* 44 App. Div. 462, 61 N.Y.S. 33 (1899), an action was brought to recover from defendant a penalty of $100 for using soft coal in contravention of a statute providing:

> No factory, engine room or electrical station shall use what is known as soft coal for fuel . . . within a radius of four miles of the city hall. . . .

The court held that it was within the police power of the legislature to declare that the burning of soft coal within certain prescribed limits of the city was detrimental to the public welfare and that the same be forbidden.

In the case of *State* v. *Tower*, 184 Mo. 79, 68 L.R.A. 402, 84 S.W. 10, the general assembly of the State had passed an act in 1901 which made "the emission or discharge into the open air of dense smoke within the corporate limits of a city in this state which now has or may hereafter have a population of 100,000 inhabitants" a public nuisance. The statute exempted the premises of owners who could show to the satisfaction of the court that there was no known practical device to prevent the emission of dense smoke. The court upheld the Missouri statute as valid and reasonable.

For other cases upon this subject, see:

- *Cincinnati* v. *Burkhardt*, 30 Ohio Cr. Ct. Rep. 350, Ann. Cas., 1918 B, 174 (1908);
- *Bowers* v. *City of Indianapolis*, 169 Ind. 105, 81 N.E. 1097, 13 Ann. Cas. 1198 (1907)
- *In re Junqua*, 10 Cal. App. 602, 103 Pac. 159 (1909);
- *City of Rochester* v. *Macauley-Fien Milling Company*, 199 N.Y. 207, 92 N.E. 641, 32 L.R.A. (N.S.), 554 (1910);
- *Ballentine* v. *Nester*, 350 Mo. 58, 164 S.W. 2d 378 (1942);
- *Glucose Refining Company* v. *City of Chicago*, 138 Fed. 209 (1905).

5. *Is There a Reasonable Classification in the Rule?*

This question involves the "equal protection clause" of the Federal Constitution. Many States have similar constitutional provisions. The clause in essence provides that the legislature cannot arbitrarily discriminate, although it can make a reasonable classification with respect to subjects, objects, places, and circumstances. The basic considerations are:

(a) Does the rule apply equally to all within its terms?

(*b*) Where a classification is adopted, is it *reasonable?*

In *Moses* v. *United States*, 16 App. D.C. 428, 50 L.R.A. 532, the statute exempted chimneys of buildings used exclusively for private residences, while declaring the emission of dense or thick black or gray smoke of cinders from smokestacks or chimneys to be a public nuisance. The statute was upheld.

In *State* v. *Dower*, 134 Mo. App. 352, 114 S.W. 1104 (1908), the court sustained a conviction under a Missouri statute prohibiting dense smoke in cities of more than 100,000 except where no device which would permit compliance existed. It was shown that the defendant was using a boiler to which no device could be attached.

In *Atlantic City* v. *France*, 75 N.J.L. 910, 70 Atl. 163, 18 L.R.A. (N.S.) 156 (1908), the court upheld an ordinance which made it unlawful to permit the emission of dense smoke from any stack connected with any engine or locomotive within the city limits, when the smoke contained soot or other substances in sufficient quantity to cause injury to health or damage to property within the corporate limits of the city; and which made no distinction between locomotive engines operated on railroads and any other kind of engine.

6. *Is Criminal Intent Necessary or Provided for by the Rule?*

The criminal intent or mens rea essential to a conviction in the case of true crimes need neither be alleged or proven with respect to violations of municipal ordinances which forbid the commission of certain actions contrary to the general welfare and make them malum prohibitum. Proof or admissions of the doing of the forbidden thing, regardless of intent, good faith, or willfulness, must bring a conviction. *People* v. *Consolidated Edison Co. of N.Y. Inc.*, 116 N.Y.S. 2d 555.

In *People* v. *Alexander*, Unreported, Appellate Department, Superior Court, Los Angeles County, Calif., CR A 2709 (1951), the defendant was charged with violating the provisions of a California statute governing visible emissions.

The court held that an instruction of the trial court was correctly given as follows:

> It is the actuality and not the guilty intent that determines guilt. Intent is not an element of the offense defined in Health and Safety Code, Sec. 24242.

C. *SPECIFIC METHODS OF REGULATION*

In drafting specific regulations or ordinances, it is well to observe that different approaches may be used. The method or methods selected will depend upon the nature of the problem and the particular source to be controlled. Some of the approaches in actual use are as follows:

1. *Control of Darkness or Opacity*

This is the simplest and the most common approach. It is also quite effective if the problem is one of smoke or other visible emission. The purpose here is to prohibit emissions which exceed a stated darkness or opacity. This method has the advantage of ease of enforcement. The Ringel-

2. *Control of the Observed Effect*

This is an approach of ancient origin, usually referred to as "nuisance." The method here is to prohibit directly the injury of persons and property. This approach has the advantage of being solidly based in the common law, but prosecutions under this type of rule are difficult because of the difficulty of proof.

3. *Control of Quality of Emission*

Here the limitation is based upon the percentage of the offensive contaminant which may be contained in a particular emission. Such rules are difficult to enforce except by employing a permit system, but they provide excellent standards for control devices.

4. *Control of Quantity of Discharge Related to Process*

Here a specific limitation is placed on the discharge, depending upon the type of process or weight of materials processed. This type of rule may also provide an absolute maximum. It has the advantage of being more logical than some other methods.

5. *Control by Required Equipment*

This approach is relatively novel. Its purpose is to require specified proper control equipment, or its equal. It is particularly useful where emissions are difficult to measure. Enforcement is very easy, compared to rules which require tests to determine whether or not they are being violated.

6. *Prohibitions of Acts or Processes*

The method used here is to prohibit nonessential acts or processes which result in contamination of the air. Prohibition of open fires and incineration is a common example. This approach requires careful advance planning, but it is quite effective.

7. *Control of Fuels or Methods of Operation*

Here the chemical composition of fuels or other materials being processed is controlled. This type of rule has long been employed in areas where bituminous coal is used for fuel. It represents a sophisticated approach, particularly where pollution is caused by a single type of industry.

Some rules, of course, combine various approaches. Some rules, for example, begin by absolutely prohibiting an act such as incineration, but

The foregoing analysis does not include every approach which may be used. Indeed, we may expect that, with advances in technology, new methods will be developed which we can not now imagine. Our experience in Los Angeles, however, has shown that all of the approaches discussed can be used effectively to reduce air pollution.

D. *THE PERMIT SYSTEM*

Separate consideration should be given to rules and regulations which provide for and regulate the issuance of permits. Not all air pollution control programs include a permit system. However, our experience in Los Angeles County has clearly shown that the most effective and positive weapon in the arsenal of air pollution control officers is the power to grant or deny permits.

Probably no serious urban air pollution problem can be effectively dealt with without some sort of licensing system. The effect of such a system is to prevent air pollution, in contrast to some of the other approaches which seek by injunction or prosecution to cure an existing emission. When it is properly applied, such a program should eventually bring under the scrutiny of the air pollution engineers each source of contamination and each control device.

It does not require a great deal of imagination to see that the enforcement of law under a permit system is far more effective than occasional visits by a violator to the criminal courts, or protracted litigation in a civil action.

E. *THE CRIMINAL PENALTY*

There are some people who express the belief that no criminal penalty should be attached to the rules of an air pollution control agency. There are still some people who suggest self-control by industry. Such programs may work under particular circumstances, but if the problem is serious or expensive to solve, they will surely fail.

In southern California we observed the inadequate efforts of self-regulation. We also noticed that it had that common fault of nearly all self-regulation plans—they seem to evaporate when the pressure is taken off. The reasons for this are not complicated.

In a hypothetical case, typical of many which we have observed, a corporation with headquarters

Angeles County. The vice president in charge must convince the home office that he is an efficient manager, but the plant develops an air pollution problem which will cost $200,000 to control. The manager then does one of two things—he tries to get by, perhaps with a cheap but inadequate system, or he requests that the $200,000 be appropriated. This request is almost invariably refused.

Under our law, violation of the rules is a misdemeanor (Cal. Health and Safety Code, Sec. 24281). This gives the local manager a very persuasive argument for his superiors, and ordinarily the necessary funds are provided.

The injunction is a fine legal tool for many purposes. It is still the "big gun" when one is dealing with a large and continuous violation. As a basic or sole remedy to defeat air pollution, we have found it to be almost useless. The chief defect in this remedy is that it takes too long. The period between the decision to file and the entry of a final judgment is seldom less than a year, and is often much longer. In the meantime the process has been changed, or the control system altered. The plant may have changed hands. The result is that little is accomplished compared with the energy and money expended.

The conclusion to be drawn from these factors is that any effective rule must rest finally upon a possible criminal penalty. Ordinances usually provide for such a penalty. If "administrative" rules are employed, then basic legislation may have to be secured to provide for the criminal penalty.

F. *CONTROL OF CONTAMINATION FROM MOTOR VEHICLES*

Probably the source of air pollution most difficult to control is the motor vehicle. Effective techniques for reducing contamination from automobiles seem to remain just out of reach of the scientists. On the other hand, concrete progress has been made in control of crankcase fumes, and all of the evidence leads to the belief that the technical problems will be solved in the near future. The problem with which we are concerned here is one of legal regulation which will result in reducing pollution from this source.

1. *The Standard*

Assuming that there will soon be available an effective control device at a reasonable cost, the statute which will make its use mandatory.

The first problem here is the standard. This may be stated in various ways, for example: (1) a limit on emission of particular contaminants; (2) a specified percentage reduction of particular contaminants; (3) the use of a control device of a specified efficiency; or (4) a particular treatment of the emission (temperature, retention time, etc.). If number (4) is used, provision should be made for any other treatment of an efficiency equal to that specified.

In the first instance, such a standard must be determined by experts in the field. Then it may be enacted into law by direct legislation or by administrative regulation.

2. *The Responsible Agency*

The second legislative problem is determining the responsible agency. Because vehicles are by definition mobile, as are the air masses, local control by cities and counties is likely to de difficult and ineffectual. Regulation by the Congress under the commerce clause of the Constitution would be desirable, but bills introduced to accomplish this have not progressed far. Moreover, many States have no serious problem from this source. Even if such legislation were passed, one could predict that its standards would reflect the least common denominator, rather than the serious problems of urban communities.

It thus appears that the State government is the proper entity to prescribe regulation of air pollution from motor vehicles. Furthermore, State governments, through their constitutional responsibility to protect the health and safety of people, as well as through their long histories of motor vehicle regulation, are ideally constituted to cope with this problem. This does not rule out supplementary Federal regulation of vehicles in interstate commerce, nor does it eliminate the traditional responsibility of local agencies to enforce the law.

Whereas the State is the ideal agency, it would be politically naive to believe that every State legislature is guided by the needs of urban areas. Situations will surely arise in which cities, counties, and districts will be left to protect themselves.

3. *The Approved Device*

At the present time, the only feasible method of substantially reducing air contamination from vehicles appears to be some sort of control device. Unless he is assisted, the vehicle owner will be unable to determine whether or not an advertised

device will meet the standard. Enforcement officers will be in a similar uncertain position. One obvious solution is certification of approved devices. This procedure is not novel, for in many States automotive equipment, such as lamps, safety belts, and safety glass, is presently tested and approved by a State agency.

4. *The Primary Enforcement Point*

It is unlikely that control devices could be developed and produced in a sufficient variety and volume to fit and equip all existing and new vehicles in a short period of time. One method of dealing with this problem would be to require all new vehicles to be controlled when first sold. The process could be accelerated by requiring used vehicles to be controlled when resold, after a fixed date, with a final cutoff date on which all vehicles must meet the standard. The primary enforcement point could be the issuance of first registration, transfer of registration, and periodic reregistration, respectively.

Systems like this one would be relatively simple and economical, and should result in nearly 100 percent compliance when devices are available. The vital weakness in this system, without additional controls, is that it would not provide any assurance that a device, once installed, would be maintained in efficient working order. This brings us to the subject of periodic inspection and control.

5. *Periodic Inspection and Control*

Periodic inspection of motor vehicles, by public agencies or by licensed inspection stations, is one method by which motor vehicle exhaust control devices could be maintained at an acceptable level of efficiency. However, if complex devices such as catalytic afterburners are used, it is likely that the problem of developing simple instrumentation and training personnel in its use will be a substantial factor. Direct-flame afterburners would be relatively simple to inspect and to maintain in good working condition. States which now require periodic motor vehicle inspection should have little difficulty in providing inspection of the less complicated control devices.

In some States such as California, the suggestion of periodic vehicle inspection can lead to near bloodshed. Perhaps no other one statute has been so often introduced and so regularly rejected. The fact remains that the average automobile owner is quite lax in securing adequate maintenance for his vehicle. This is true even with regard to safety equipment, and the outcry would be greater still in the case of air pollution control devices. Unless there is developed a device which needs little or no maintenance, some sort of inspection will be the only alternative to an ineffective overall motor vehicle control program.

6. *When to Adopt Controls*

One may ask why legislation cannot await the full development of near-perfect and inexpensive motor vehicle control devices. One answer is that many years elapse, in the usual case, between the submission of a new proposal and its final enactment into law. Part of this delay is due to the fact that many State legislatures do not convene every year.

Probably a more important factor is the chicken-or-the-egg dilemma. A valid statute requires an available device. However, as we have seen, the manufacturers are unwilling to commit themselves to a substantial production program unless and until they are assured that their particular product will be acceptable. The passage of enabling legislation, with an escape clause to deal with the possibility that unforeseen delay may occur, seems to be a practical escape from the dilemma.

7. *Legislation in California*

In 1960, at a special session of the Legislature, California adopted the first comprehensive act designed specifically to require vehicle exhaust control devices (California Health and Safety Code, Div. 20, Ch. 3). It would be beyond the scope of this paper to discuss the act at length. However, persons charged with preparing legislation of this type may be interested in the California approach.

The law creates a Motor Vehicle Pollution Control Board which must determine criteria for approval of control devices and also is required to conduct tests on devices submitted. When two or more devices are approved, motor vehicles may not be sold or registered (after specified periods for new, used, and commercial vehicles) unless they are equipped with approved devices. Counties with no air pollution problem may be exempted by action of their governing bodies.

The progress which the control board has made to this date has convinced those of us who are familiar with the problem that the California legislation is fundamentally sound. We have observed no need for substantial amendment to it.

CONCLUSION

In the foregoing paragraphs we have discussed the "mechanics" of legislative and regulatory action in the control of air pollution. It should be observed, however, that no set of principles can furnish a design for a particular regulation to solve an individual problem. This is true because the drafting of regulations requires a good deal more than mechanical application of a pattern. On the other hand, the experienced legislative draftsman always begins his work by searching for an existing statute or regulation which has been tested. Thus, some of the first air pollution legislation was borrowed from statutes designed to abate other types of nuisances. The Ringelmann Chart was similarly adapted to air pollution regulation.

The most important mechanical device involved in regulatory action has not been discussed above. That device is the lever which starts the process in motion. In our experience, the drafting of effective legislation and regulations is not the most difficult problem in this field. The hardest task is taking the first step toward air pollution control. Almost everyone, from the homeowner to the steel manufacturer, has a reason for wanting to pollute the air. Powerful groups will attempt to gain exemptions or favorable treatment for themselves. Some will suggest that self-regulation be encouraged. Others will recommend more studies and research. If the responsible members of the community yield to these arguments, then one result can be predicted with certainty—the people of that community will continue to breathe contaminated air for a long period of time.

With our present legal knowledge and with the application of existing scientific and technical skills, air pollution can be defeated as a serious menace to our urban population. The elements which we must supply are the courage and the initiative to enter the arena.

Prepared Discussion: THE MECHANICS OF LEGISLATIVE AND REGULATORY ACTION

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May I first compliment Mr. Kennedy on the high quality of his paper and the thorough consideration he has given the subject? Probably no one in America is as well qualified by training and experience to speak on this subject.

Probably he has the advantage of geographic location, for where but southern California would one have such an opportunity to embrace firsthand all of the aspects of legislative and regulatory action in connection with air pollution? For many reasons the Los Angeles County situation may be considered unique. Mr. Kennedy's contribution to the solution of these problems in Los Angeles has been immense and his paper is a scholarly analysis of his subject. It does him great credit.

My brief remarks will approach this subject from a slightly different direction. Mr. Kennedy speaks as an extremely able and experienced government official charged with primary responsibilities in this field. I speak as a Pittsburgher and as a practicing lawyer who has seen these problems both as a citizen in the Pittsburgh area and as counsel to industries which have become involved with air pollution problems, both in the regulatory field and in the courtroom where damage actions have been tried.

My remarks will be directed principally to the thesis announced by Mr. Kennedy that air pollution control regulation and enforcement should be commenced and vigorously pursued as soon as possible, even though the problem has not been so analyzed, investigated, and researched that the precise aim or goal of the regulations has been determined.

As I understand it, Mr. Kennedy states with firm conviction that governments should not wait for scientific research to be completed and until the exact causes of the undesirable condition have been determined. He advocates that immediate steps be taken, as I believe Los Angeles has in fact done, to abate "all emissions." To oversimplify it, this is the shotgun approach, to crack down on everything in the hope that the source of the real trouble, though not identified, may be cured in the process. The result, of course, has a very pronounced economic consequence and of necessity results in large expenditures by both the government concerned and the affected sources of emission that may, it seems to me, be quite out of line with the results obtained. I suppose the justification for such an approach is that the illness is so acute and dangerous that everything must be tried, in the hope that one of the medicines given will produce the hoped-for result.

Certainly from a plain economic standpoint, it is much more desirable to discover first what is causing the illness and then direct the medication to that cause. If the patient is dying, perhaps there is no other alternative, but, in the case of most community air pollution problems at least, I question the feasibility of the shotgun approach which some say puts the cart before the horse. I wonder if Mr. Kennedy would not agree that a great deal of time, effort, and money had been wasted in Los Angeles in inoculating the patient against diseases which were not producing the symptoms to be cured. No doubt his reply would be, "But look at what we have accomplished."

My brief remarks are in nowise intended to be critical of Mr. Kennedy's paper, because it is a fine contribution to the subject. Still, I take it that the

directors of this program desire a real discussion of varying viewpoints, and so this is mine.

To me, the two most important pillars of a legal structure through which air pollution abatement is to be achieved are, first, a law which will encourage the full utilization of technical knowledge, because this is a highly technical problem; and second, to the extent industry is involved in the program, a law designed to give industry encouragement and authority to take the responsibility for achieving abatement.

I think all will agree, for example, that the success of our program in Pittsburgh and Allegheny County (and admittedly our problem is quite different from the problem of Los Angeles) is the high degree of cooperation developed between governmental and industrial sources, all desiring the same end—cleaner air. Thus, I am convinced that, to the extent industrial pollution is involved, the prime object is to have such a law, and so administer it, that full industry cooperation is encouraged. Air pollution abatement is largely a matter of economics, and so, to preserve the competitive factors, the requirements of the law must be applied equally and fairly, and industry must feel that the expenditures required of it are worthwhile and will really help the problem.

Industry, with very few exceptions, will do the job and cooperate fully if it is satisfied that those publicly charged with the job of air pollution abatement are honest about their attempt and competent to treat with the subject matter. I refer to the use of the Ringelmann chart, for example (and Mr. Kennedy and I have discussed this before), which I believe is so unscientific in some of its uses that industry is likely to be less than enthusiastic about control measures which utilize this gross type of measurement. Perhaps that is only a detail, but I believe it illustrates the point and, since industry trying to do a good air pollution job would not rely on a Ringelmann chart to make its own monitoring measurements, it therefore can be expected to be less than enthusiastic about the merit of a program that uses the Ringelmann chart for enforcement.

I believe too that air pollution problems are essentially local and unique, so that abatement legislation which does not recognize the local uniqueness of air pollution problems is bound to miss its mark.

Lastly, I would like to observe that in establishing maximum emission levels we are approaching a subject of extreme gravity to industry. While the establishment of maximum emission levels is rather a Utopia from the standpoint of the enforcement official, unless such standards are very carefully established on the basis of real scientific data, tremendous hardship can result without corresponding gain, and what is worse, from industry's standpoint, industry will lose confidence in the program if it believes the emission levels are established without a sound, scientific background.

It has been a pleasure to appear briefly on this program with Mr. Kennedy and to repeat that his paper is an extremely valuable contribution to the legal basis for an air pollution program in action.

THE ROLE TO BE PLAYED BY LOCAL AND STATE GOVERNMENT

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In developing this subject it seems appropriate to consider the purpose of government intervention, the objectives of air pollution control programs, the activities of State and local agencies, and the problems of implementation. Obviously such matters can only be sketched briefly in this analysis.

NECESSITY FOR GOVERNMENT INTERVENTION

When the public interest is involved and when cooperation of a number of parties is required for effective results, we begin to have a basis for government intervention. The adverse effects of air pollution on the health of people; damage to vegetation, animal life, and property; and interference with normal community life are ample evidence of the propriety of community concern. These effects of air pollution are the subjects of other panels. For our purposes we can accept the statement of the American Public Health Association (APHA), Air Hygiene Committee (*1*), "Air pollution has been recognized as a problem of increasing significance to the health of the nation. Further, the degradation of communities ensuing as an aftermath of excessive air pollution saps the nation's social and economic vitality. As such, it demands the most effective use of the resources of all levels of government."

Voluntary efforts of industry to curb air pollution are laudable and to be encouraged. Yet, in a competitive market, complete reliance on voluntary efforts is basically unfair since the worst polluter may be avoiding the cost of air pollution control, and this may allow his products a price advantage. Government action based upon sound laws and regulations assures equitable requirements for all.

Industry and the public seem to have accepted these views. As John Yocom points out in a recent article in Chemical Engineering (*2*) "Air pollution control is here to stay. Not only are new local control agencies springing up all over the country, but the public is asking existing agencies to adopt new regulations that would affect more and more processes." Yocom continues by stating that ". . . it is no longer fruitful for industry to argue whether or not it should be compelled to make sometimes expensive provisions to reduce plant emissions to the atmosphere. The questions now are: How should control regulations be written, and how can compliance best be achieved?"

From these observations we can evolve two important criteria:

1. Regulations should be effective in protecting the public.
2. Regulations should be reasonable in relation to need.

Historically in the United States air pollution control originated with efforts to abate smoke and then flyash. Pittsburgh and St. Louis made notable progress in this field. Since then interest has extended to gaseous pollutants, and the need for control of objectionable odors is now recognized. Now, the public is satisfied only with the agency that can effectively cope with all of these problems.

Local and State legislation in air pollution control is based upon the police power of the States. This power of the States may be delegated to local governments through their charters and through

years, there has been a trend to seek more specific State laws which positively authorize air pollution control activities of State and local agencies.

Because the basic laws are sometimes difficult to change rapidly and legislators do not like to become involved in technical details, many administrators favor the creation of a rulemaking body—an Air Pollution Control Board, a Board of Health, or a similar board—with authority to adopt regulations to implement the broad legislative policy and objective. Such boards may also hear appeals from administrative orders. These boards should not have executive direction of the agency's activities, as this negates the responsibility of the executive branch of government. Proper selection of board members can assure representation of a variety of community interests in the promulgation of standards.

PROGRAMS BASED ON NEED

The premise that the extent of air pollution control measures should be based upon need seems fundamental. To ascertain need for control requires a survey of conditions. A publication of the American Public Health Association (APHA) entitled *Health Officials' Guide to Air Pollution Control* (*3*) will provide information useful to making a survey. Basically, such surveys inventory what is being discharged to the atmosphere through stacks, exhausts, etc., and also sample the air to determine the dispersion of pollutants throughout the community.

If we favor control activities based upon need, then each community must be considered on an individualized basis. The Manufacturing Chemists' Association (*4*) points out that "Each localized air pollution area is unique." The Air Pollution Report to the Governors' Conference (*5*) states that ". . . the control of air pollution should be assigned to the lowest level of government capable of dealing with the problem in its entirety." The APHA Air Hygiene Committee (*1*) advises ". . . that enforcement of laws designed to control polluting emissions from specific sources can best be accomplished at the lowest level of government capable of effective action. In practice this means that the area of operation must be of sufficient size and of such characteristics that the control of sources of emission within the area will substantially ... petent staff and required services."

All of these statements recognize that the effects of air pollution are usually realized near the source, and the demand and support for control efforts is there. In most States, it is highly unlikely that a State agency could be as responsive to a local condition as one under the control of the citizens of the local area. Furthermore, when one considers need, it is likely that needs will vary from one local area to another, and it would be difficult and impractical to administer regulations on a statewide basis without regard to local need. It would be like using Miss America as an ideal and then manufacturing all women's dresses in America to her measurements. You can imagine how they would fit!

While problems, and accordingly, needs, vary from one local area to another, there are fundamental precepts which can be used as a basis for laws and regulations. The APHA Subcommittee on Health Aspects of Air Pollution (*3*) has proposed a definition of air pollution as the presence of contaminants in the atmosphere ". . . in such quantities and of such duration that they are, or may tend to be, injurious to human, plant or animal life or property, or which unreasonably interfere with the comfortable enjoyment of life or property, or with the conduct of business."

There are those who claim that control should be based only on standards for the general atmosphere which are founded on specific health effects. These same parties will then point to the imprecise knowledge in this field and suggest that control await further research. This is merely a delaying tactic. There is a considerable amount of engineering knowledge that can be readily applied to curtail unnecessary air pollution. The community has every right to demand that this know-how be used now to eliminate soot and dust and obnoxious odors and to provide a clean community in which it is a joy to live.

Harold W. Kennedy (*6*) in a recent paper analyzes a number of court decisions related to air pollution control. He makes the point that ". . . control measures need not await definite standards of air quality. It is a part of the greatness of the police power that it does not require a foundation of perfect knowledge. No legislative body has ever possessed perfect knowledge, and the courts do not expect or require it."

These observations strengthen the thesis that each community must determine the quality of air it requires. City advisory groups which represent all interests are recommended for this purpose. Health must be protected, but beyond that, the community may establish its own criteria for air quality as related to its own social and economic development.

ACTIVITIES

In planning specific control activities it should be recognized that the citizen may experience the effects of two basic kinds of air pollution, either independently or simultaneously. One is the nearby or "across-the-fence" nuisance or damage caused by the discharge from a single source. The other is the concern for contamination of the general air mass over a community. The latter may be insidious in that normal sensory perception may not alert us to its presence. However, concern for area-wide pollution can lead us to forget and neglect the neighborhood problem.

Both of these types of air pollution problems need to be considered in planning urban development. Zoning and redevelopment are vital tools in reducing the effects of pollution. The "across-the-fence" pollution nuisance can be minimized by separating residences and offensive operations such as rendering plants through zoning. To be effective, however, the industrial area should be similarly protected by zoning from encroachment by residences. Such zoning practices should not be used as an excuse to avoid controlling air pollution to the extent of current engineering ability, because the general pollution of a community's air will not be relieved to any great extent by zoning. Planned development of an urban area can be used, however, to keep to a minimum the concentration of pollutants in an extremely localized area.

Yocom (*2*) gives a number of illustrations of the application of specific air pollution control regulations. The APHA Air Hygiene Committee report (*1*) outlines typical activities conducted by State and local agencies. The committee recommended the following assignments to the various levels of government:

a. The Public Health Service should provide vigorous leadership in the national effort. It should initiate broad investigations and research to define the problems of air pollution, their effects upon health, and feasible methods of control. The Public Health Service also has the duty to encourage the training of personnel, to disseminate information, and provide consultation to State and local agencies.

b. The State health department is responsible for the overall investigation and interpretation of the air pollution problem in the State. It should also provide planning at State level, and when needed, foster the development of effective programs at lower levels of government through consultation, information, and technical assistance. Normally enforcement should be at local levels, but for special situations, like moving sources (auto exhausts), direct State action may be required.

c. Local health agencies should assess the air pollution problems of the area served and establish criteria for the control of specific sources of pollution. This requires monitoring the air, sampling stack discharges, and surveying operations and activities of industry and the public. Enforcement of laws and regulations is a local responsibility. Prevention of air pollution should be encouraged through review of plans, instructions to operating personnel, and public information activities.

PROBLEMS OF IMPLEMENTATION

If so much is known about means and methods for the control of air pollution, then why has there not been more accomplished? The fact is that in some places a great deal has been done, and this work provides an example for others. However, there are serious problems that can be discussed.

It is not enough for an agency merely to point out that pollution exists. In severe cases there are any number of citizens who could readily cite the presence of pollution. The agency must be staffed, equipped, and supplied with facilities to determine the cause, and to advise and instruct concerning acceptable solutions.

If there are problems with combustion processes, there is need for practical combustion engineers to show firemen and operating engineers how to operate their equipment to avoid smoke. When stack discharges are sampled and the atmosphere is sampled, there must be available chemists, engineers, and laboratory facilities for performing analyses. The agency must either provide these, contract for them, or receive these services from State agencies. Plans review requires engineers who can judge the performance of proposed installations. Studies of health effects in the local area require medical epidemiologists and statisticians. Studies of atmospheric phenomena call for meteorologists on the staff, as consultants or on loan from State agencies.

To provide these services places additional strain on the already burdened urban governments. A 1956 study (*7*) of 46 local air pollution control agencies revealed that they spent a median of 8 cents per capita. Similar surveys in 1961 (*8*) and 1962 (*9*) revealed that expenditures were in the same order of magnitude. During this period sal-

aries and other costs were rising. Thus, the net effect is that effort had to diminish. Furthermore, this amount is woefully inadequate to pay for the cost of a reasonably comprehensive air pollution control program. Financial as well as technical assistance to local agencies is obviously needed to stimulate an increase in local efforts.

Companion to an increase in expenditures must be a program of training and recruitment of the necessary technical and scientific manpower. The recent expansion in State and Federal activities has drawn men from local programs. Industry and consultant firms have also attracted experienced men from local departments. Financial assistance to students and also to educational institutions, for expansion of their capacity, seems to be a national problem and warrants action by the Federal Government through the Public Health Service.

While much is known that can be applied, there is great need for research. More knowledge of health effects would help establish more precise standards and might avoid some of the hysteria that prevails sometimes at present. We need to understand more about phenomena that occur in the atmosphere. Procedures for sampling and analysis are far from standardized. Industry, professional societies, and educational and research institutions have a place in such efforts along with the Public Health Service, but this Federal agency should provide leadership to stimulate these efforts.

We have not yet considered the impact of the great social movement of our age—urban development. A recent survey (*9*) of 159 local agencies reported nuisances were caused by air pollution sources outside the jurisdiction of the control agency in 62 percent of the cases, and it was believed that external sources affected the general pollution level in 52 percent of the localities. Control of such sources poses difficult questions in intergovernmental relations. The Advisory Commission on Intergovernmental Relations begins its report (*10*) by stating that "at no point in the structure of the American Federal system of government are problems of intergovernmental relations so marked, varied, and difficult as in the large metropolitan areas, where the activities of all three levels of government function in close proximity." Not only are there several levels but also a great number of autonomous local units of government which in relation with their neighbors frequently behave not unlike the nations of the world. There have been attempts to achieve coordination through cooperation, contract for service, special-purpose districts, countywide government, and multi-county arrangements. Toronto's Metro and the Bay Area Air Pollution Control District are receiving particular attention.

Interjurisdictional questions extend across State lines in a number of instances. State and Federal interests are thus both involved in seeking a solution to this question, which not only is technical but also has social and political dimensions.

CONCLUSION

To conclude, the increasing magnitude of air pollution and the mounting health significance require the resources of all levels of government to protect the public health and preserve the vitality of our communities. A heavy burden, in the application of control measures to curb sources of air pollution, rests on the local agency. These local agencies urgently need technical and financial assistance from the State and Federal Governments. Furthermore, there are problems which require State and Federal action to be effectively handled. Through coordination of these efforts we may achieve our objective which was so well phrased by Dr. James P. Dixon (*11*), ". . . air is still essentially for breathing."

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Prepared Discussion: THE ROLE TO BE PLAYED BY LOCAL AND STATE GOVERNMENT

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The paper by P. W. Purdom very substantially establishes the role of government as translating the needs and desires of the people into action programs based upon legislative regulations. Each level of government has its own role to play and these roles should not conflict with or duplicate each other.

The premise that control of air pollution should be assigned to the lowest level of government capable of dealing with the problem in its entirety is generally accepted. The selection of the governmental unit closest to the problem and capable of dealing with it sometimes gives rise to question.

It has been said that the extent of governmental intervention depends upon the need and the desires of the community. The desires of the people are made known through public pronouncements of the citizenry and direct communication with the legislators. However, the need of the community is wrapped up in a highly complex set of political, scientific, social, and economic parameters which, at the present state of our knowledge, is sometimes difficult to define.

In the development of a community control program, it is frequently stated that no community is like another. The author quotes the Manufacturing Chemists' Association as advancing the premise that "each localized air pollution area is unique." This should not be taken too literally. One community can learn from another, provided problems and environment within the community are similar. However, for a midwestern city to decide that the photochemical smog problem in its community needs the same type of legislative program as the urban areas of California, without such need being based firmly upon fact, would be a serious error.

There has been a great deal of technical discussion in recent months about establishment of air quality standards as a basis for control programs. The point made by the author, that control programs should not be held in abeyance until this work is accomplished, needs to be stressed. The work towards establishment of standards should be energetically pursued but, in the area of nuisances, the people of the community will not be silent. The role of government in this area is to assess the situation, develop the control measures, and proceed toward abatement of all significant sources of air contamination. When standards come, they can be integrated into the program to more firmly establish the foundation for the community air sanitation effort.

In the matter of zoning as a protection from "across-the-fence" pollution nuisance, a word of caution is in order against placing too much dependence upon this tool in itself to reduce the effects of air pollution. It is true that distance will shield neighbors from the heavy settling solids. However, distance is a very poor shielding factor for odors and the finer nonsettling aerosols. In certain situations, distance combined with unfavorable terrain can produce air pollution nuisance many miles removed from a source.

Another word of caution concerns the air pollution survey. Surveys, unless they are well planned and complete, to cover all of the suspected pollutants within an area, can be misleading. They must extend over a sufficiently long time period to cover seasonal variations in the weather and even then the unusual weather may not show up in the one-season survey. A case in point is the relatively high oxidant levels (peak 24 parts per million) observed

in the city of Cincinnati in the summer of 1957. During 1958 no value higher than 13 parts per million was reported. If the survey had been limited to 1957, considerable concern would have developed over the effects of photochemical smog. However, had the survey been run only in 1958, the community would have built up an unwarranted sense of security from this type of air pollution effect.

The requirements of an air pollution control program will range from the part-time services of a qualified individual for a very small community to a completely staffed air pollution control organization as described by Purdom. The success of the local program is the never-ending vigilance to seek out emission violators, the constant monitoring of the air quality, and the rigid engineering control over new equipment installation and land uses to deter future pollution sources.

In the matter of costs for air pollution control, the author points out that the median investment in cleaner air for the cities surveyed both in 1956 and in 1961 approximates 8 cents per capita. It should be strongly emphasized that 8 cents per capita will not purchase an air pollution control program suitable for the average urban community, regardless of its size. Speaking before the 1962 annual meeting of the Air Pollution Control Association (*1*), J. J. Schueneman stated: "Local air pollution agencies, with a few exceptions, do not have large enough budgets to support the kind of program they need." H. C. Ballman at the same meeting (*2*) stated: "On 40 cents/capita/annum, any community of 200,000 or more could maintain an intensive program."

The city of Cincinnati has a better-than-average air pollution control program involving the necessary elements of engineering control, enforcement, air monitoring, and administration. The cost of this program is more than double the 8 cents per capita quoted above and still falls far short of the investment by the community in other city services. For example, in 1962 for every dollar invested in the air pollution control program, the city of Cincinnati will spend \$5 for building inspection, \$13 for total health services, \$57 for fire protection, \$62 for police protection, and \$10 for water pollution control. I am sure that a study of the relative dollar investment in municipal services would show a similar relationship in other communities.

Like the author of the paper under discussion, the writer is a local control official. The State of Ohio is a recent entry into the air pollution field, so there has been little opportunity for personal observation of the services available from the State organization. State support of a local program by technical and financial aid would stimulate local cleaner air effort. It appears proper for a State to adopt general regulatory statutes on emissions and to furnish guidance and lend support to local programs. It is incumbent upon the State to provide for control over mobile sources of air pollution, typical of which is the automobile, should such control be found necessary. It would be impractical for a State to enter the field of control in the urbanized areas which are capable of supporting an adequate control program. In the smaller communities which would be affected by a complex source, or an unusual problem within its own confines or nearby, the State could furnish the technical assistance necessary to bring the source under control.

In conclusion, it is observed that the author, P. W. Purdom, has done a most thorough job in casting the role of the local and State government in pursuing the goal set by every community engaged in a control program—outdoor air of salubrious quality—thereby promoting the maximum enjoyment of life and property for its people.

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Prepared Discussion: THE ROLE TO BE PLAYED BY LOCAL AND STATE GOVERNMENT

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INTRODUCTION

In a paper delivered June 8, 1961, S. M. Rogers (*1*) of the U.S. Public Health Service stated in part: "The Federal system requires strong, responsible State governments. The degree to which the States satisfy the governmental needs of modern society determines in large measure the strength of the whole system. The diversity of local needs requires action whenever possible at the State and local level." Harold W. Kennedy, county counsel and attorney for the Los Angeles Air Pollution Control District, has established that ". . . almost all regulation of air pollution is founded upon the police power of government. . . . The police power delegated to cities and counties is not all-embracing, however, in that the State may take such power unto itself. . . ."

From this base and by tracing threads of common thought contained in the papers by Mr. Purdom and Mr. Gruber, we can reach certain conclusions.

NEEDS OF A COMMUNITY

Both Mr. Purdom and Mr. Gruber agree that regulations should—

1. Protect the public.
2. Be based on the need of the community, as indicated by surveys, for example, of—
   (*a*) the over-the-fence problem; and
   (*b*) the area problem.

All speakers have agreed that we should not wait for the end of all air pollution research or the final determination of the health effects on individuals. On the other hand, we should not act when partially or totally uninformed. There are two conclusions which I believe have not been brought into focus.

1. Little has been said about the determination of the needs of the community. This is a vital point. Needs should be determined by more reliable methods than individual complaint or "rough and dirty," subjective, inventory-type surveys to which a number of States and localities have been exposed. Adequate techniques and knowledge are available to obtain actual samples of the air on which to base the need for reduction of pollutants.

2. As Mr. Kennedy states, ". . . the legislature can declare air contaminants to be a public nuisance . . . provided that the . . . declaration is reasonably clear and certain. . . ." Because of varied individual definitions of what constitutes a health hazard, it is my conviction that if all air pollution is controlled at a nuisance level, which is a well-established pattern, we may not need to concern ourselves with the gravity of adverse health effects upon the individual. If adverse health effects of a permanent nature can be demonstrated, the health laws are available to handle the air pollution.

We should cease to bandy about numbers, such as references to 6,000 or 10,000 communities requiring air pollution control programs. These numbers have not been factually determined and it may be that only 1,000 communities require active programs. How many communities today can point to an air sample (monitored data) taken 10 years ago to com-

pare with an air sample taken today . . . or how many are preparing now to obtain monitored data to compare with data gathered 10 years hence?

The proverb "necessity is the mother of invention" may be changed to suit the successful air pollution control program. The need for a program, soundly assessed, will develop competence for correction; conversely, competence without sound assessment of the need will never develop the wholesome desire for air pollution control programs.

SUCCESS OF ACTIVE PROGRAMS

The success of active programs now in progress at city, State, county, and district levels is in direct relation to the effort made by a control agency to determine "what's in the air" with the best technology available (ofttimes devising its own). The great informational gap today is lack of factual knowledge of the air pollution levels of over 90 percent of our metropolitan areas. The sootfall jar and the dirtiness factor, although they are still part of a monitoring program, can no longer be the sole indexes to air pollution. More sophisticated survey programs are required. More communities must have air quality data based on monitoring.

GOVERNMENTAL ACTIVITY TODAY

Sixteen State governments and over 250 communities are actively engaged in air pollution control (*2*). This is quite an increase over 10 or 15 years ago, when only one State had authority to control air pollution and about 100 communities had ordinances. The future is even more encouraging; within the next 2 years 5 to 10 more States and approximately 50 communities, to our knowledge, will consider new air pollution legislation, many of them favorably. This is in addition to those States and communities which are updating their present ordinances and rules and regulations. We believe the States and local government legislative bodies are fully accepting their responsibilities in obtaining general and more intensive control of air pollution.

FUNDS—COMPETENCY

Funding an air pollution control program has been the most serious problem for most agencies. Only a few agencies have sufficient funds to do an acceptable job. Mr. Purdom points out that the control program should be assigned to the level of government able to finance it properly. In the instance of smaller States, such as Rhode Island and Delaware, this would in all probability be the State itself; in other instances a group of communities in a county or a district would form an agency. Such districts would also have to give consideration to the area in which air pollution originates and in which the effects are found. Such an area may cross political boundaries.

The greatest reason for lack of support of an air pollution control program is the lack of factual knowledge of the need, based on air sampling or, if I may be so bold, the need on which the program is sold. Monitoring and intensive surveys are the most critical part of a program to finance. Who wants to spend money to find out what is in the air, although this is the greatest need? Funds for this purpose, if available from the Federal and State governments, should find a most important application in the determination of quality of air over our metropolitan areas. Police power should remain with the States or their delegated governmental agencies, and all efforts should be exercised to keep these powers unencumbered. But to determine the culprit which may require policing—this is an area of mutual interest to all levels of government, including Federal agencies.

CONCLUSION

Role of State Government

The State government should maintain its present police powers in air pollution control by accepting its responsibility to actively participate in—

(*a*) Enabling cities, counties, districts, or metropolitan areas to join for united efforts on common problems.

(*b*) Specifying areas requiring the joint efforts of several governmental subdivisions and activate subareas legislatively, including financing and regulatory powers.

(*c*) Establishing a body in the State government's administration to—

1. Deal with and make recommendations for State action on interstate problems.

2. Manage personnel and equipment, and work with subdivision governments of the State to determine air pollution by surveys, and act in an advisory capacity on air pollution problems.

3. Receive Federal funds for the support of monitoring and surveying activities by the State agency for the smaller communities.

NOTE.—Larger communities with intensive air pollution programs should be permitted to negotiate with the Federal Government, with the full knowledge of the State agency.

Role of Local Government (City, County, District, Area, Etc.)

1. If no control program exists, the local government should establish a body (commission, committee, etc.) to explore—

(*a*) Which areas contain pollution sources.

(*b*) Which areas are affected by air pollution (general area problem or over-the-fence problem).

(*c*) State assistance available for an intensive survey on which to base corrective measures.

(*d*) Financing of a control program, should one be required. (Gruber states that this program may range from the part-time services of a qualified person to a fully staffed air pollution control department.)

(*e*) Necessary legislation based on needs found from the survey.

(*f*) Support of a continuing program.

NOTE.—This same outline can be followed if a voluntary program is considered in those smaller communities with only a few sources of over-the-fence-type pollution.

2. If a program exists, the local government should establish a body (commission, committee, etc.) to explore—

(*a*) Whether basic problems have been correctly evaluated.

(*b*) Area of control—is it sufficiently inclusive?

(*c*) State facilities—are they utilized fully?

(*d*) Financing—is it sufficient?

(*e*) Regulations—are they adequate?

(*f*) Local and State support—is it adequate?

It is necessary for all local government functioning bodies to work for adoption of State legislation which will most realistically solve the problem.

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THE ROLE TO BE PLAYED BY THE FEDERAL GOVERNMENT

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In the 1955 legislation setting up a Federal research and technical assistance program to combat air pollution, Congress outlined the role the Federal Government is expected to play in combating this problem.

It was declared to be the policy of Congress to preserve and protect the primary responsibilities and rights of the States and local governments in controlling air pollution. But Congress recognized that an important role could be played by the Federal Government in supporting and aiding technical research and in providing technical services and financial assistance in the formulation and execution of air pollution abatement research programs. This assistance was not limited to State and local governmental air pollution control agencies, but was made available to "other public or private agencies and institutions."

It was not long before suggestions were made to expand the Federal assistance provisions. Some of these suggestions were discussed when the act was extended 4 years in 1959.

In February 1962 the Secretary of the Department of Health, Education, and Welfare transmitted to Congress a draft of a bill to extend the area of Federal activity, which included authorization for grants to State and local control agencies for the development, initiation, or improvement of control programs, and also authorization for the Surgeon General to detail, upon request, personnel to air pollution control agencies.

Unfortunately, due to the heavy schedule of hearings on transportation, communications, public health, food and drug, aviation, and other legislation, the Committee on Interstate and Foreign Commerce of the House could not give the Secretary's recommendations adequate consideration. Accordingly, the existing program was extended 2 years to give the committee time to review the Federal Government's role in meeting our increasing air pollution control problems.

That authority exists to expand the Federal role no one doubts, if Congress in its wisdom feels that an expansion is necessary and would produce desired results.

The welfare and commerce clauses of the Constitution vest great authority in the Federal Government to promote commerce and protect health and property in the public interest.

It is not my purpose to discuss the extent of that authority here. Instead, it will be more fruitful to discuss the responsibilities of the Federal Government in the field of air pollution control. I am sure that in meeting this problem of air pollution we can all agree that the Constitution gives the Federal Government all of the authority it needs to meet its responsibilities.

We legislate in the field of health to promote the general welfare, although apparently the first Federal health legislation was to promote commerce. So, we are on firm constitutional ground in appropriating Federal funds to study the effect of air pollution on human health.

Air pollution can and does affect both air and surface transportation, and from that standpoint the Federal Government has an interest in the effect smoke and smog have on commerce, but no one is suggesting now that the Federal Government could or should regulate the burning of trash in Los

Angeles to prevent interference with air commerce or ground transportation.

In that connection, let me say that I do not think the Federal Government has any business telling the people of, say, Birmingham or Los Angeles how to proceed to meet their air pollution problems. That was made clear in the 1955 act. Even if Washington attempted to exercise such authority, we would have a hard time writing and enforcing regulations at long range. The effort would be not only difficult but also expensive, and without the cooperation of local citizens, very little could be accomplished.

But there are things the Federal Government can and should do to help local communities combat air pollution. Those things were spelled out in the 1955 act. In addition to assistance in conducting research, that act authorizes the Surgeon General to encourage cooperation of State and local governments in preventing and abating air pollution; to collect and disseminate information; and to conduct investigations and surveys on request of State and local agencies.

Research is of vital importance in our attack on air pollution. But research is costly. The Federal Government can do the job more efficiently and at less cost than the 50 States, operating independently. Even if the States had the money, skilled manpower is limited, and duplications would be unavoidable.

Thus, Federal leadership would seem to be of first importance in getting the necessary research done as quickly and as cheaply as possible.

The Federal Government also makes an important contribution by collecting and disseminating information. Where research results are not made readily available, waste and duplication result. In view of the importance of the study on exhaust fumes made by the Surgeon General, the Committee on Interstate and Foreign Commerce is making every effort to give the report in June 1962 the widest distribution possible to scientists, public officials, and others interested in this problem.

The 1955 act not only contains no provision for Federal enforcement activity but specifically provides that the rights and responsibilities of the State and local governments are to be preserved.

That, of course, does not mean that the Federal Government cannot go a lot farther if the need arises. For example, in 1957 Congressman Schenck of Ohio, the ranking Republican member of the Subcommittee on Health and Safety, introduced a bill to prohibit the use in commerce of any motor vehicle which discharged unburned hydrocarbons in an amount found by the Surgeon General to be dangerous to human health. The committee was unwilling to go that far but the bill led to the enactment of the Schenck act in 1960, directing the Surgeon General to investigate the effect of motor vehicle exhaust fumes on human health and report to Congress. That report was made last June and has been widely distributed.

Just what will be the outcome of the studies being made by the Surgeon General and in California no one knows, but if Congress decides such drastic action is necessary, there is no doubt that legislation along the lines of the original Schenck bill could be enacted and enforced.

But that is something vastly different from the Congress enacting legislation to regulate the burning of trash in Los Angeles. Motor vehicles by the thousands move across State lines daily and the States acting individually might find it difficult or impossible to exert effective control over exhaust fumes without unduly interfering with interstate commerce.

In summary, it would seem that abatement and enforcement programs to be effective must remain the responsibility of States and local governments, but there is a vast field in the area of research and the dissemination of information where the Federal Government must continue to take the lead.

With the full support of Congress, the Public Health Service is spending millions on health research. Studies to date prove without a doubt that air pollution is a major public health problem. We must continue our study of this problem with increased vigor.

Prepared Discussion: THE ROLE TO BE PLAYED BY THE FEDERAL GOVERNMENT

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I agree with Congressman Roberts that the Federal Government has constitutional authority to regulate air pollution which affects the health and welfare of our citizens and I concur with his thoughts that the Federal Government should conduct research and promulgate information already being developed throughout the United States. However, I would go beyond Congressman Roberts' conception of the Federal Government's role, and endorse the "declaration of policy" stated in H.R.13343, introduced by Congressman Rhodes of Pennsylvania on October 4, 1962. The most important part of the declaration of policy states that the Federal Government has an obligation to provide leadership in the initiation of national programs of research and development, and the policy further suggests that the Secretary of Health, Education, and Welfare be authorized to direct a concentrated national effort to achieve the prevention and control of air pollution within the next 10 years. I would like to comment now on the specific areas in which the Federal Government should concentrate its activities to fulfill its stated objectives.

(1) The Federal Government should develop guidelines applicable to the establishment of interlocal, intercounty, and interstate agreements to effect air pollution control on a metropolitan area basis, which would allow local governments to individually implement their specific programs. Federal development of these guidelines should assure the development of unbiased, objective mechanisms for agreement. The desirability for the adoption of specific regulations by each local community to administer the requirements of local control programs is recognized but, in a metropolitan area with possible interstate problems, it may be necessary to sacrifice strictly local-level control in the interest of obtaining legislation which would be of benefit to the entire metropolitan area.

The Metropolitan Chicago area, as defined by the Chicago Association of Commerce and Industry, is composed of eight counties; six counties are in Illinois and two are in Indiana. This 8-county area is composed of 1,000 independent political jurisdictions with a population of 7 million people and a projected 15 percent population increase every 10 years. The multitude of political jurisdictions in our area points up the need for guidelines which would allow all such jurisdictions to conduct air pollution control programs independently if they so desire. Further, such guidelines should provide as an alternative a suggested procedure whereby political jurisdictions could agree on a district approach to air pollution control if the particular jurisdictions felt this had specific advantage in solving their mutual problem.

(2) The Chicago metropolitan area, as defined above, and other metropolitan areas in the United States have definite interstate pollution problems and point up the growing need for the adoption of Federal regulations for resolving such problems. The most outstanding problem in this area is air pollution from automobile, truck, and bus exhaust and blowby. The only realistic long-term and permanent solution for the control of this moving source of pollution is the adoption of suitable Federal legislation. The Interstate Commerce Act of 1935 established safety regulations for motor vehicles specifically concerned with their operation and

equipment. This decisive act in the public interest to reduce highway accidents and resulting deaths may be the precedent for Federal action today in the control of pollution from these vehicles.

(3) In addition to legislative needs for coping with motor vehicle pollutants, those of us living in the Chicago metropolitan area see the need for the development of interstate compacts or, as a last resort, the provision of appropriate Federal authority for dealing with the many stationary sources of pollution which have pronounced interstate effects. Any mature air pollution control program for the city of Chicago will require the cooperation and action of contiguous political jurisdictions within the State of Indiana and the county of Cook in Illinois, if Chicago citizens are to have the clean air they are now demanding. The control of stationary pollution sources within the city's corporate limits alone will not accomplish this. Realizing the importance of this, the mayor of Chicago, Richard J. Daley, late last summer invited Congressman Roberts and his Subcommittee on Health and Safety to Chicago to hold congressional hearings on this matter. We hope that Congressman Roberts will be able to schedule hearings in the near future.

(4) Congressman Roberts stated that "Studies to date prove without a doubt that air pollution is a major public health problem." Most of us working in the air pollution field recognize the general validity of this statement, but we find it most difficult to justify our local program from a health standpoint by merely stating that evidence points towards the existence of relationships between air pollution and public health.

Rather than such a qualitative relationship, the need exists for quantitative correlations between air pollution and public health to better define and justify our goals when implementing a local air pollution control program. The necessity for continued, increasing research which will identify specific pollutants with specific diseases cannot be overemphasized.

(5) In the Federal Government's research program, increased emphasis should be placed in the area of ambient air quality standards. In the absence of accepted standards giving nonobjectionable pollution levels, it is quite difficult to give our public satisfactory answers regarding the needs of a local control program or the degree of existing pollution. Such air quality standards would satisfy local needs and have nationwide application. These recommendations for acceptable air quality levels should be such as to provide a good environment for residential, industrial, and commercial activities.

(6) Federal assistance at the local level for a community starting a new control program or improving an existing program would be most helpful in the following specific areas:

(*a*) Recommendations for at least minimal laboratory facilities. These should include suggestions on space and equipment, and on educational requirements for laboratory personnel.

(*b*) Circulation of bulletins on analytical laboratory procedures. The bulletins should be updated frequently to take full advantage of research on new analytical methods.

(*c*) Development of technical library facilities.

(*d*) Methods for conducting emission inventories. These suggested methods should include descriptions of techniques for stack sampling and also for making estimates of emissions based on predetermined emission factors for specific processes.

(*e*) Employee training programs.

(*f*) Data processing systems.

(*g*) Analysis of air pollution complaints with a view toward using them to the best advantage for improvement of control practices.

(*h*) Survey of sampling methods and equipment requirements. These should include survey plans for various population and area conditions, and cost estimates for equipment. We know that the Public Health Service already has done excellent work in the Nashville study and in other studies, but we could reap more benefit from the results of these studies if the findings were published in more usable form, perhaps by presenting significant facts in a single publication.

(*i*) Expansion of Federal laboratory facilities for conducting detailed chemical analyses requiring facilities beyond the scope of local agencies. This would be most helpful in solving problems pertaining to identification and quantification of pollutants from specific problem areas.

The city of Chicago has just entered into a 5-year technical aid and assistance agreement with the Division of Air Pollution, Department of Health,

Education, and Welfare. This agreement encompasses many of the above items; the most important are, presently, an emission inventory and an updated air monitoring program.

(7) The Chicago regional offices of the Public Health Service have been most helpful to the City of Chicago Department of Air Pollution Control in establishing a long-range local control program and coordinating our efforts with the Federal program. The importance and success of such liaison and consultation services as we have experienced in Chicago leads us to suggest that such a program should be expanded in all Public Health Service Regions, particularly in those regional offices where full-time air pollution personnel have not been assigned.

DISCUSSION

W. Lawrence Faith. My question should be directed to Harold Kennedy and it may not be fair to expect the answer from Robert Barsky, who read Mr. Kennedy's speech in the latter's absence. But perhaps, if Mr. Barsky doesn't answer, Mr. Seamans will. One of the major regulations in the basic California law is the equivalent opacity regulation. There is considerable doubt in the minds of many as to whether or not the equivalent opacity law meets the doctrine of reasonableness. I say this not because I'm against the Ringelmann chart, which I believe is a reasonable way of measuring black smoke. Used in this way, it not only provides a measure to help prevent the soiling of surfaces and fabrics but at the same time it also is within reach economically of the legitimate enterprise in the community which is putting out the smoke. This is not necessarily true, however, of equivalent opacity. In my mind, there's no relationship between equivalent opacity and the efficiency of an operation. There's also no relationship between equivalent opacity and the unwanted effect. So why did they put this in the California law?

Robert M. Barsky. Not all pollution is smoke or soot or carbonaceous. You also have iron oxide pollution. You have many different kinds. You have sulfurous pollution. Why should the color of the pollutant be the determinant for a regulation? It doesn't really matter whether it's black or red or yellow. The kind of pollution that is being attacked is pollution that doesn't belong in the air. It's our sense of esthetics it offends. And it may or may not be a health menace. The important thing is that it's there and it's visible and it shouldn't be there. I think our attitudes about this regulation typify the two philosophies that we've heard expressed here. One of them that I think Mr. Ballman stands fairly and squarely for is that industry, or any people who want to use the air for purposes other than breathing, have some sort of inherent right to pollute it or to use it for their purposes up to the point where it becomes a nuisance or impinges upon their neighbors. There is another point of view, and I think you know that we in the Los Angeles Air Pollution Control District stand for this one. And that is that nobody has a right to pollute the air. That the basic right is the right to have free and unpolluted air. And those who want to use it as a public cesspool have the obligation to prove to those who have a right to clean air that their activities are not going to produce pollution. Hence I think this kind of an opacity regulation makes very good sense.

Ballman. In all deference to my panel brother, I should like to say that I have been misquoted. I am not asking that all industry commit nuisances. I think that if my paper is read carefully, and if I am listened to carefully, I suggested that nuisance values be used as standards. And, if you wish, I'll add a safety factor below nuisance value. This then would eliminate the possibility of adverse health effects. I should like to be quoted properly rather than interpreted as Mr. Barsky has done.

Seamans. There's certainly a lot of philosophy you can get into here. In regard to the specific question Dr. Faith asked about the Ringelmann chart and the opacity test, there was a case in the Los Angeles district where the opacity test had been sustained by the California court. The U.S. Supreme Court declined to entertain a writ of certiorari. So I guess the legality of the opacity test is established; it is now the law of the land.

W. J. O'Connell. As chairman of the Advisory Council of the Bay Area Air Pollution Control District, I have some comments on Mr. Kennedy's paper. For about 40 years, I have worked with him frequently on local and State legislation affecting air and water pollution. I therefore join Mr. Seamans in recognizing his ability and the sincerity of his excellent reviews of the law. However, he makes two flat statements that in my opinion are not true insofar as air pollution control practices in California are concerned. One is that a permit system is essential, and the other is that the injunctive procedure is at least clumsy, if not wholly unworkable. First of all, the basic nature of the law under which a district is operating must be recognized. In the case of the Bay Area Air Pollution Control District, the regulation is a performance regulation in its entirety. The district does not have any criminal action powers at all. A violator is referred to a hearing board, a quasi-judicial board made up of three men, one of whom must be an attorney, one a registered engineer, together with a third, all chosen at the will of the board of directors. This hearing board is in no way responsible to the board of directors. The staff and the board of directors refer cases of violation to the hearing board. If the hearing board finds in fact that the person is in violation, it then has a right to set up the conditions under which the violator may continue his operation or be enjoined

the hearing board order, the findings of the hearing trial is certified to the Superior Court. No opportunity is given for a trial de novo unless there has been administrative abuse. The court then confirms the order and issues a cease-and-desist order or an order directing the violator to operate in accordance with the direction of the hearing board. Immediately thereafter, in the case of a further violation, the man is in contempt of court. And these cases are handled with dispatch. One case involved a fine of $1,500 and 60 days' imprisonment for the offense. I want to assure you that the industrial family on the west coast does not look with favor on a violation of injunctive order and the risk of contempt of court. This type of legislation can be effective if it is written so that it is workable.

William J. Harnisch. I am on the National Law Committee of the Air Pollution Control Association and am also legislative counsel of the Youngstown Sheet & Tube Co. The 1955 legislation providing a Federal research and technical assistance program should be continued. I agree with Congressman Roberts that the abatement and enforcement program, to be effective, must remain the responsibilities of State and local governments. It was the consensus of the first day's plenary session and clearly shown by the remarks of those present that the present Air Pollution Act should not be extended to provide Federal control and enforcement. Regulations should be local and tailormade to fit local conditions and problems. Communities differ greatly in their needs, and what is economically feasible for one area might be harmful to another. California's exploding population growth, its peculiar atmospheric conditions and geographical location, its heavy motor vehicle concentrations, and its lack of extensive industrialization make for stringent regulations and dangerous problems not present in other areas of the country. What may be necessary for California could be unnecessary for New York. And if national standards were applied, they would cause great economic damage, create vast industrial unemployment, and weaken our national economy. The legislator or administrator should first ascertain that there is a problem and what it really is. Then, before adopting laws which perhaps cannot be complied with, the legislator must be sure that there are economically feasible methods for solving the problem. Most effective regulations can be achieved by enlisting the Voluntary cooperation is more effective in controlling air pollution than constant action by control officials. Industry after industry in the United States has spent millions on uneconomic air pollution control equipment in order to voluntarily clear the air. The control legislation should be carefully considered to make sure that no economic damage is done to any person or industry unless absolutely required for the common welfare.

Legislators have the responsibility not to enact control for control's sake. It is poor statesmanship and will be resented by the voters to enact unnecessarily strict regulations without regard to the gravity of the problem, the economic feasibility, and the technical know-how for controlling the source of pollution. We can clear the air through Federal research and technical services, State and local reasonable legislation, and voluntary cooperation of industry and the citizens of our community.

Mitchell R. Zavon. Mr. Fitzpatrick, if I understood you, you implied that it was necessary that we quantify the health effects of air pollution in order to complete the job of air pollution cleanup. Why is this necessary? Wouldn't it be sufficient justification for cleaning up air pollution to show economic loss?

Fitzpatrick. It makes my job easier as a Chicago control official to relay to the public the need for air pollution control if we have this quantification of the health effects. I didn't wish to imply that the economic effects should be discounted by an aggressive or intelligent air pollution control program.

Zavon. In actuality, this may not be true if all the evidence regarding local air pollution resulting from the smoking of cigarettes and other forms of local contamination has made as little impact on the public as it has. I doubt very much if further scare techniques regarding general air pollution will have any additional effect. I believe that the driving search for adverse health effects from air pollution may not really serve any particularly constructive purpose in cleaning up air pollution, although it may be desirable for other reasons.

Fitzpatrick. I appreciate your reinforcing my point. We don't want to use scare techniques in a program; we want definite scientific proof if we are going to relay this to the public.

Harry Morrison. As assistant manager of the Western Oil & Gas Association, I represent that association's point of view at this conference. I

speak in wholehearted support of two recommendations which pertain to this panel and which you heard presented in detail at the plenary session yesterday by the California Supervisors Association. They had also been approved by the California League of Cities, the Los Angeles County Air Pollution Control District, and the Bay Area Air Pollution Control District. It appears to me that these recommendations go to the heart of the responsibility designated to this panel, and to the heart of the conference itself. Since we have all agreed that air pollution must be fought at all levels, what we are seeking is the proper and most efficient method of allocating our governmental and legislative responsibilities.

The first recommendation was that the U.S. Public Health Service should be authorized by Congress to conduct studies in local areas to determine the existence, scope, severity, and cause of air pollution problems, at the express invitation or upon the express consent of the State or local authority. We believe that the role of Federal Government, as embodied in the Public Health Service, should be to conduct studies on air pollution problems, at the invitation or with the consent of the local entity. The important words here are "studies," and "express invitation" or "consent." It is significant to go back to the evolution of this first recommendation, back in California, from the form in which it first came before the group. It recommended hearings and investigations with no limitative provision for the invitation or consent of the local entity. However, in the discussion that led to the final recommendation for hearings only, it was pointed out—and I wish to emphasize again before this panel—that the words "hearings" or "investigations" connote recommendations with ultimate followthrough which may well lead to the concept of enforcement. This enforcement would be ultimately by the Federal Government, and it has been stated much to our satisfaction today, throughout this panel by all of the speakers, and I was particularly pleased by the words of Congressman Roberts, that it is not the intent of the Federal Government to go into the enforcement field.

The second recommendation was that the Public Health Service should be given the authority to undertake, and to assist in the financial support of, State and local air pollution research programs. The important word here is "research." Again referring to the historical development of this recommendation, it is again significant to note that it originally provided, as it came before the group in California, for grants and aids to local entities in direct support of their normal agency operation. The important words here are "direct support of their normal agency operation." Here again, with the unqualified and unanimous approval of the Supervisors Association of California and the League of California Cities, the support of normal budgetary operations by the Federal Government should not be either supported or requested. The local people, who feel it is their responsibility and who are doing an exceedingly fine job, have accepted the close relationships that lie between the people of the community and their locally elected responsible officials; and these relationships are necessary to provide adequate control with the safeguard against Federal intervention that has been the hallmark of our democratic system.

In no way do I wish to imply, nor do I want it to be inferred, that we have anything but the greatest respect for the U.S. Public Health Service, the work it has done, the contributions it has made, and its real place in the fight against air pollution. Indeed, our association together with the local District, the State of California, and the U.S. Public Health Service began back in 1956, when we participated in a joint effort which created the benchmark for refinery pollution. This in itself was a great step forward in that we had had the full cooperation of the refining industry and the Federal Public Health Service, along with that of our local and State entities. I believe that it is of the utmost importance to note that in California, where air pollution problems have been very great and where most progress has been made, all of this has been accomplished with the local entities in complete control of regulation, aided and abetted through these years by the strong support of the U.S. Public Health Service. I use these words *aided* and *abetted* advisedly because these are the words of the Surgeon General as he spoke to the Nation this morning on the television program "Today."

In closing let me summarize what Surgeon General Terry said. He felt that the U.S. Public Health Service should have the same role in air pollution matters as it has had in other fields in which it has a responsibility; that there should be a coordinating role to help States get together, to stimulate and to support research; that it should aid in State or project grants on a matching basis; that technical and professional people should be made available to work with the States and other control entities. As

I mentioned previously, he said his concept was that of aiding and abetting, that local government must take the lead, that there must be a local willingness to assume responsibility, and that the main initiative had to come in the local area.

I urge that this panel adopt these two recommendations in their final report for the plenary session tomorrow.

Schulze. I am going to ask that the remaining speakers, if they have statements rather than questions, restrict their remarks to 2 minutes.

William J. Conner. I am speaking for the Manufacturing Chemists' Association Air Pollution Abatement Committee. This association represents 90 percent of the production capacity of the chemical industry of this country, and its keen interest in air pollution abatement activities is indicated by the fact that we have had an active committee operating in this area since 1949. In respect to the subject under discussion today, we certainly agree that voluntary cooperation by the public, even though it is important, is not enough. We say this even though we are proud of the distinguished record of many of the members of our own group in voluntary abatement of air pollution. We also feel that control activities cannot be simply postponed until we have all of our research programs completed. By this, however, we do not mean to endorse arbitrary or whimsical prohibitions; only sound legislation and regulation, reasonably applied, will help us to achieve improved air quality.

If this is what we need, how do we go about getting it? It should be mentioned that pollutants do occur naturally in the air—from dust, storms, fires, volcanoes, etc., and we also have to reckon with those. Our obligation is to avoid seriously degrading the air as it comes to us. For this purpose we have to have some carefully formulated criteria for measuring the quality of that air. Developing these ambient air quality criteria to control our pollution requires the work of a substantial group of qualified scientists, with adequate financial backing. We think that Federal resources are definitely needed to help accomplish this task. The public concern for cleaner air is growing, but it hasn't yet been translated into adequate funding of State and local air pollution efforts and we can't simply wait for that. One thing we can do is to help work for such adequate funding of local effort; the other is to support Federal assistance to the State and local agency by grants-in-aid, surveys, research, and technical help; and our members do support this Federal assistance to local agencies. In summary, our views parallel Congressman Roberts' views in this matter and we should like him to know that MCA supports him in his stand. We will also support his bill if he introduces one along these lines. If we see any ways to improve that bill, we will certainly feel free to say so, and if we can contribute anything out of our experience, we hope you will call upon us.

Eugene H. Clapp II. I represent a small—and I emphasize small—pulp and paper manufacturer in New England. It seems to me that, both in the panel papers and in the statements so far from the floor, everybody has been talking about the Federal Government or State problems in terms of large communities, large industries, and large groups. I wish to say a word for the small manufacturer and the smaller community. Just as in the case of water pollution, where municipalities create the greatest source of stream pollution, in the field of air pollution too, the municipality is a large creator of air pollution. Industry is always decried as the greatest air polluter, but all individuals everywhere across the land, as private citizens—through the use of automobiles, incinerators, and home heating furnaces, and leaf or grass burning, etc.—are major contributors to our present air pollution problem.

In this instance, the public officials, particularly those in Washington, seem to have lost sight of the importance of ability to pay; they also seem to have lost sight of the almost insurmountable problems that would face small companies and small communities if the Federal Government were to preempt this field. Some of this country's most vital wartime industries, such as steel, pulp and paper, and lumber, are operating today on a break-even or on a loss basis; to add any cost whatever is impossible for the small producer in these industries. This could well be the last straw to force them out of business. Local authorities understand local problems, particularly those of small industries. The Federal Government and its elective and appointed officials have no conception of the magnitude of these problems, and an unwise air pollution law such as the Neuberger bill could spell the deathknell of many small companies. I urge local solution by local authorities, even interstate-compact types of legislation, rather than any preemption of this field by the Federal Government. Federal Government intervention would be the most costly

and the least likely to operate in a sensible and sane fashion.

Peter J. Short, Jr. As a representative of Lukens Steel Co., in a field of industry that is greatly concerned with this problem, I wholeheartedly subscribe to and support the philosophy outlined in Congressman Roberts' paper about the role of the Federal Government in the field of air pollution. Let me quote the lines I refer to. "It would seem that abatement and enforcement programs, to be effective, must remain the responsibility of State and local governments, but there is a vast field in the area of research and dissemination of information where the Federal Government must continue to take the lead." I too am confident that the individual States are fully competent to cope with their air pollution problems without additional Federal legislation.

R. Clyde Hargrove. As a representative of the Tennessee Gas Transmission Co., I am addressing a plea to the legislators who write the regulations and to those who administer them to try to avoid a recurrent problem which has plagued regulated industry almost from its inception. That's the problem of overlapping jurisdiction between regulatory agencies. To cite one example of immediate concern, the Los Angeles County Air Pollution Control District imposes rule 62, which in practice requires the powerplants in that county to burn gas during part of each year. All competing proposals to supply gas to that area for that purpose have this much in common: None can be accepted without the approval of the California Public Utility Commission or the Federal Power Commission, and usually both. These two commissions thus have a virtual veto power over rule 62 in its present form and under present conditions. The difference between the two is illustrated by the fact that the staff of the Federal Power Commission and the staff of the Los Angeles County Air Pollution Control District are just about as far apart in their appraisal of current situations as it is possible for two staffs to be.

For the future, it seems to me, after observing the course of regulation for quite a long time, that despite the many hopes expressed at this meeting for local control, Federal control is literally inevitable in this area and, since local controls will also still be maintained, you will have the same problem with which the utility industry is faced—overlaps between the local and the Federal regulatory agencies. This problem may be impossible to solve, but it certainly can be abated if those agencies try to achieve the maximum degree of cooperation in their operations and regulations.

A. J. Cochrane. I thoroughly agree with Mr. Seamans' and Mr. Gruber's comments on Mr. Kennedy's paper about legislative and regulatory action, as well as with their preference for local control of local situations. In achieving the broader application of legislative and regulatory control techniques to air pollution, there is no substitute for mutual understanding and respect between the regulatory agency personnel and those regulated, and for the wholesome cooperation which stems from such mutual respect and understanding at local levels. Furthermore, the progress made in air pollution legislation today at local levels is due to the cooperation of local air pollution officials with industrial associations and committees dedicated to a mutually satisfactory economic solution of air pollution problems. With these achievements in mind, I agree with Mr. Seamans and Mr. Gruber that air pollution problems are local and that differences between local areas require different local legislation to provide good regulatory know-how to each unique local situation.

Schulze. I think this is a rather interesting development. Everybody at this panel seems to agree that local control is the best control. Mr. Fitzpatrick pointed out that there are certain areas in which Federal control might be indicated, as Congressman Roberts did in the case of motor vehicles. Yet the audience seems to be primarily concerned with retaining strictly local control.

CONCLUDING REMARKS

SIDNEY EDELMAN
Chief
Environmental Health Branch
Office of General Counsel
U.S. Department of Health, Education, and Welfare
Washington, D.C.

As a legal panel, I think we have achieved a remarkable degree of unanimity on legal questions. It is fair to say, on the basis of what we have heard here this afternoon, that the panel members agree that there are no serious legal obstacles to the adoption of laws or regulations for the control of air pollution.

But this rather large area of agreement does not mean that the application of legislative, regulatory, and administrative know-how does not involve elements of controversy. We have to consider both private and public interests concerned with the resolution of the complex problem of air pollution control; and our discussion has indicated that the reconciliation of these interests, which sometimes seem to be in conflict, should not necessarily be approached solely on the basis of determining the furthest extent of permissible governmental action without a clear demonstration of a need for such action.

I think our consideration of the problem has also indicated acceptance of the view that air pollution control is here to stay. In terms of this panel's attitudes, even the discussion we have heard about local versus Federal control indicates that no one is questioning whether or not control is here. As John Yocum has said, "it is no longer fruitful for industry to argue whether or not it should be compelled to make sometimes expensive provision for reducing plant emissions to the atmosphere. The questions now are these: How should control regulations be written? And how can compliance best be achieved?" [1]

[1] Yocum, John E., "Air Pollution Regulations—Their Growing Impact on Engineering Decisions," Chemical Engineering, July 23, 1962.

A community confronted with a serious and perhaps an acute air pollution problem, and with only limited knowledge of the causes and effects of air pollution, may nevertheless decide—as has been indicated here—that the most effective method of control is to attack every source. This approach can also be supported, as pointed out by one of our speakers, on the ground that there is a considerable amount of engineering knowledge which can be readily applied in detail for air pollution control. The community has every right to demand that this know-how be used now.

But it sometimes demands also that action for the control and abatement of air pollution always be based on accepted technical criteria. It seems to me that this approach assumes that there has been an orderly and progressive development of air pollution programs going hand in hand with the development of scientific and technical knowledge. This just hasn't happened. There is a lack of precise technical information upon which to base an air pollution control program. This lack, however, must be viewed, not as an indictment of our lawmaking process, but as a challenge to our scientific resources. Until this gap is closed, reasonable governmental action to protect the health, welfare, and safety of the public can be legally based, as was pointed out here, on the best information available, even though all parties concerned are aware that more information would be desirable.

The question of the importance of research and the necessity for financial support of research have been emphasized by a number of speakers today. It has been said here that responsibility for research into the phenomena of air pollution and into its health effects should be shared among industry,

professional societies, educational and research institutions, and the Public Health Service; and that the Federal Government should provide the necessary leadership. As Congressman Roberts said, Federal leadership is important in getting the necessary research done as quickly and as cheaply as possible.

In the discussion of the Federal role, one speaker endorsed the "Declaration of Policy" contained in the so-called Rhodes bill introduced in the last Congress, H.R. 13343, which states that the Federal Government has an obligation to provide the leadership in the initiation of national programs of research and development. While it was indicated that there are some problems which may require Federal intervention—I hesitated to use the word "intervention," but Federal intervention seems to me more exact than Federal *assistance*—to resolve if local governments are incapable of doing so, there seems to be a general agreement, as our chairman indicated, that control of air pollution should be assigned to the lowest level of local government capable of dealing with the problem in its entirety. The capability at the local level was coupled with emphasis on the necessity for obtaining the cooperation of government, business and industry, and the public in the development and application of local ordinances and regulations.

The President of the United States, in his statement on the 14th annual Cleaner Air Week declared that "fresh, clean air is not a privilege to be granted or denied; it is a right which we must preserve if we are to enjoy healthful productive lives." He went on to state that "pollution of the air is not necessary; it can be controlled and perhaps eventually prevented by the cooperative action of all our citizens."

I think that the exchange of views and information, both on the local level and on the national level—such as we have had here today, for example—would help in providing a solid basis for cooperative action by the public, business and industry, and government in moving ahead with the development of air pollution controls which will meet our national needs.

Panel H

APPLYING OUR PUBLIC INFORMATION AND SOCIOLOGICAL KNOW-HOW

Applying Present Know-How to Air Pollution Control

Chairman: JAMES DIXON
Co-Chairman: JOHN W. BODINE
Reporter: ARTHUR A. ATKISSON

Participants

JAMES DIXON, President, Antioch College, Yellow Springs, Ohio

RACHEL CARSON, Biologist and Author, Silver Spring, Md.

GILBERT SELDES, Dean, The Annenberg School of Communications, University of Pennsylvania, Philadelphia, Pa.

PETER H. ROSSI, Director, National Opinion Research Center, University of Chicago, Chicago, Ill.

JOHN E. BEBOUT, Director, The Urban Studies Center, Rutgers, The State University, New Brunswick, N.J.

RONALD BROOKS CAMERON, U.S. Congressman-Elect, Pico Rivera, Calif.

JOHN W. BODINE, President, Penjerdel, Philadelphia, Pa.

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OPENING REMARKS

JAMES DIXON
President, Antioch College
Yellow Springs, Ohio

We are all sorry that Miss Rachel Carson is unable to be here. Had she been able to speak to us, I suspect that she would have undertaken to define certain "givens"—operating truths if you please—which are relevant to our task.

What are these truths?

First, the atmosphere plays a crucial role in the outcome of the processes which we call life. Not only the finiteness but also the quality of man's existence is affected.

Second, the atmosphere through its composition and movement has potentials for both good and evil impact upon human life. As presently viewed, the balance due to the discharge into the atmosphere of the physical byproducts of 20th-century knowledge offers more prospect of death and unacceptable alteration of life than of the protection of a continuous process of creative human evolution. In short, we are faced with a revolutionary dilemma.

Third, knowledge while still imperfect is sufficient to inform action in the creation and enforcement of public policy.

Fourth, the democratic value system requires that public policy not only concern itself with immediate problems but also offer opportunities for better lives for our progeny.

Fifth, not only does contamination of the air endanger fundamental biological systems, it also offends our esthetic values. This fragile system of values by which man rationalizes the pleasure of existence is enormously affronted by the centripetal contraction of the physical horizon, strange scents in the nostrils, or the denial of the pleasure of growing green plants.

In the face of such overpowering truths, how can it be that reaction is so slow, so pedestrian, and so minutely scaled? I find five reasons which help me to account for this dilemma of a conservative response to a revolutionary threat. First, there is uncertainty about the effects on our pluralistic economic system of the imposition of controls on pollution and pollutants.

Second, we do not understand the implications of a new politically held power in the sovereign state. I refer of course to the power of massive nuclear destruction. We find it difficult to understand that now the conservative position is no longer to idealize the *status quo ante hominem* but the *status quo post*-Hiroshima, and for the liberal the problem is to confront the possiblity that destructive power in political hands can be turned to constructive purposes.

Third, unlike the manner in which we manage other conservation problems, we have permitted and indeed encouraged the development of public policy in matters pertaining to air pollution at the lowest rather than the highest levels of government.

Fourth, we are generally uncertain about the relationships between information, which is to say knowledge, and social action, which is to say politics. How can truth be distinguished from cant? What are the differences between the intellectual and the political definitions of truth and excellence? How do our communication systems operate in the shaping of public policy and social action?

Fifth and finally, do those persons most concerned with social action, that is, the physical scientists and their informed associates, the frightened public, and the concerned politicians, know enough about the nature of the ways in which people and groups react to external threats? Are they taking into account present knowledge, and if they find this insufficient, are they encouraging research?

Our task today is directed toward a refinement of the description of these and other roadblocks to action. And particularly, our task is to inquire into the contributions which the social sciences may make to more precise definition. The hope, of course, is that ways will be suggested which will circumvent these barriers which now obstruct action and that the fields of communication, sociology, and political science will offer new resources in the evolution of a more successful strategy in this three-cornered struggle between man, his systems, and his environment.

STATEMENT SUBMITTED FOR THE RECORD
(In Lieu of Keynote Remarks)

RACHEL CARSON
Biologist and Author
Silver Spring, Md.

It is a matter of great regret that I am unable to address the National Conference on Air Pollution as planned, but exhaustion and a severe cold have forced me to accede to my physician's orders and cancel engagements for the next several weeks. I should like, however, to send my greetings to the participants in the Conference, and especially to those in Panel H. It is an important forward step that the Conference is being held, for it implies governmental recognition of a most serious problem and desire to focus public attention upon it.

It seems to me that air pollution should be viewed in the larger context to which it belongs. It is part of one of the most vital problems that confronts mankind today: how to control the spreading contamination from many sources that is rapidly causing the deterioration of our environment. In biological history, no organism has survived long if its environment became in some way unfit for it. But no organism before man has deliberately polluted its own environment.

Pollutants in air, water, soil, and food—consisting of radioactive materials as well as of harmful chemicals—all interact to produce a serious impact on the living organism. These various problems perhaps need to be attacked separately, but the place of each in the whole must not be forgotten if intelligent and fruitful solutions are to be found.

Although the subject is complex and beset with technical difficulties and economic problems, public understanding and determination will carry us far toward our goal. I am sure this conference will contribute to such understanding.

HOW CAN WE GET ACTION FOR CLEANER AIR THROUGH PUBLIC COMMUNICATIONS?

GILBERT SELDES
Dean, The Annenberg School of Communications
University of Pennsylvania
Philadelphia, Pa.

My special assignment at this conference is to put before you some practical methods of using public communications to help in the general objective—the control of air pollution—the reduction of air pollution. Since I do not know what most of you know, I dare not say the "elimination" of air pollution.

There are ways in which this special problem is identical with other problems. These are the ones I can be most dogmatic about. It is harder to be full of assurance about those aspects of your problem which are special to you.

In the past few years I have discussed the use of the mass media—print, broadcasting, the movies—with such Federal agencies as the Department of Agriculture, with departments of mental health in individual States, and with organizations devoted to furthering legislation or social action of various kinds.

You share several things with such groups:

You need to know how these various media operate.

You need to gain access to them.

And you must know what each of them does best as well as what all of them can *not* do for you.

And your problem also differs from the problems of others. Here again I must make a guess and it will be easier for me to offer you a contrast with some of the other guesses I have made and which have been accepted by those who knew their own special problems.

By "guess" I mean the formulation I have given to problems I discovered in the literature of the various groups I worked with and in preliminary discussions. For instance it seemed clear to me that there were two obstacles in the way of agriculture making known to people what the actual situation is in our country today. One is the persistence in the back of our minds of the picture of the comic-strip hick or rube or hayseed. This figure was probably obsolescent when it appeared in the 1880's in rustic plays, and a generation ago in Keystone comedies and other movie jokes. It probably gained a new lease of life through hillbilly music. In any case it is not relevant to the tractor-tilled, irrigated, large-acreage farm of today. The second obstacle is simply the confidence of urban and suburban populations that food is going to be supplied to them. The price may vary—but no one is perturbed. A vast indifference to farming and its problems and potentialities dominates the country.

The situation in mental health is different. Here you have a marked disinclination—a positive hostility. Our society seems to be divided into two groups—those who do and those who do not have problems of mental health within their circle of family or near friends—and neither group has in the past wanted to hear about the subject. Here also we have mental images—going as far back as pictures of Bedlam—and they contribute. But the basic need for those working in mental health is to persuade people to hear about it.

This is not to say that there are not specific problems in each of these cases. But on the judgments here represented it is clear that the chief objective in using the mass media is to effect a change of

atmosphere—the atmosphere in which the message (whatever we decide the message must be) will be received.

It is simplest for me to assume that in the case of the pollution of the air the same thing is required. Indeed, the subject seems to compel me to say that here also we need a change in the atmosphere of reception. I am not sure of my ground, but I would say that the obstacle you face differs from the others I have mentioned in this: Everyone agrees on the facts—everyone says the situation is intolerable. And with the exception of yourselves and a few friends, everyone seems to feel that nothing can be done about it. You may prove that something has been done about it, but the mind falls back on a couple of verifiable facts: There are a lot of motor cars in cities and there are a lot of factories, and you aren't going to get rid of either, so why talk about cleaning the air?

Compared with the deceptive images, the indifference, and the hostility we have met in other fields, this uninformed hopelessness seems to be easier to overcome. I am not sure that this is the case. For one thing, the hopelessness has bred a kind of courage—a foolish fortitude. We become blinded and asthmatic and we curse—and we survive. And we fall back on our sense that our civilization absolutely cannot exist without corrupting the air we breathe.

Let me now utter a few professional platitudes about communications as a whole.

The first is a nonscientific version of a highly technical analysis of the process by which communication is achieved. You can find it in full in the works of Claude Shannon and other magnificent technicians. I draw from them the simple principle of redundancy and noise. By noise is meant not only the jamming of or interference with your radio signal; noise is a short term for every impediment to complete delivery of the message sent. If you do not speak Turkish and the man you are addressing knows no other language, your ignorance and his both are noise. If you need to give information to a blind man, blindness is a noise between you. And what you do to overcome this obstacle is called redundancy. To the Turk you give a picture or make a gesture—which you wouldn't do to someone who spoke your tongue. To the blind man you read the directions clear on the map he cannot see.

I think the reason this is called redundancy is that the classic instance comes from newspaper cables. Suppose a correspondent has cabled "Prime Minister flying Washington Tuesday" and a change occurs. If he cables "Prime Minister not flying" . . . and so on, there is a chance that the word "not" may be omitted in the cable and he is afraid that his office will think he is merely repeating his previous cable. So he cables "Prime Minister not repeat not flying Washington . . ." The "repeat not" multiplies enormously the chance that the true meaning will arrive . . . but it is redundant because if the first "not" gets through, the "repeat not" is superflous.

I've stressed this basic simplified principle because it falls in with what I've been saying about obstacles between you and those whom you want to interest—arouse—or persuade. I say "obstacles between" and even that is inaccurate because you are yourself an obstacle. I am myself an obstacle to complete and easy communication with anyone because the exact way I talk, my pronunciation of some words, the vocabulary I use—all are special to me and parts of these may grate on the ear of one person, offend another, and so on. Then there are the obstacles at the receiving end—the tubes—physical or psychological, may be worn out, the wave length may have been altered. And in between there are the difficulties provided by the medium itself—the printed word cannot be heard, the radio description cannot be seen, the color TV or movie picture may present a green face and a bright red sea.

Another platitude we discover is that people who intend to tell other people something assume that everybody knows what everybody is supposed to know. My favorite example was on a placard I saw every day for 2 years when I was living in New York. It said: "57th Street entrance to bridge closed. Use other street." By what intuition you were supposed to know what other street, I never found out. Going by there the other day I discovered that the 57th Street entrance was no longer closed—or perhaps I'd gotten used to the sign so that it became part of the scenery to me. That, by the way, is another pitfall of communication.

One thing I know I do not have to spend time on here is the reluctance which some people, specialists among them, feel about letting the laymen in on what they know. When I was asked to give a title to a talk I made to a group of doctors in general practice, I suggested "Should doctors speak Latin?" on the not-too-tenable ground that they still write their prescriptions in Latin. The breed of specialist who prides himself on not writing sim-

ply is diminishing—and we have proof here today that even when you are dealing with intricate scientific subjects, it is possible to write with supreme beauty of language.

There is one other general principle—the one on which you may most rely if you want to breed courage and hope. It comes from the work of the Canadian economist Harold Innis and again I give it to you in simplified form: Every basic change in the means of communication is followed by a profound change in the structure of society. The most familiar case is, of course, the coming to Europe of movable type and the collapse of the entire feudal system which followed.

We are now in the midst of a revolution in the means of communication. We are shifting from print to the electronic sound-and-sight. We can expect great changes—and we need to know how to take advantage of them.

I return now to your personal needs. First, to know how the various media operate. Knowledge, that is, of how they are used professionally, not so much their techniques. What commitments has your newspaper or broadcasting station? What have the managers learned about their capacities? By learning this you learn to ask for the kind of help you can get—not the impossible.

Gaining access—this is the old question: Which comes first. If the public is interested in and concerned with your problem, print and broadcasting will seek you out. But in order to make the public interested, you need the media first. There is no easy answer to this. One thing is sure: Your chances are a hundred times better if you know the skills and crafts—if you know how to surprise people into being interested, perhaps, in one medium and how to make information acceptable in another.

And knowing what cannot be done well—what perhaps cannot be done at all. I am not erecting artificial barriers. I am saying that the various media have different capacities. Not only because of the equipment they use, but also because of the way people use them. You can teach algebra by television in school—quite possibly the atmosphere of home limits you to arousing an awareness of what algebra is—and perhaps a desire to learn more.

Possibly in your case print may be the vehicle for spreading alarm which, as Paul Revere discovered, is not a bad thing to do. Perhaps you need a group psychologist as well as a dramatist to put over what you must say on the air.

The study of public communications is relatively new. The school with which I am connected is one of perhaps 20 in the country. Given a generation or two we could provide you with all the effective knowledge you need for your work. But you cannot wait.

And you must not despair. Whenever I meet a sort of defeatism—the sense that we cannot do anything against the vast forces opposed to us—I remember that a tiny minority, less than 5 percent of the population, was represented in Philadelphia when the document was written which began boldly—"We, the people of the United States . . ." It was a magnificent bluff for that tiny minority to make—but in 20 years the bluff was made good. And if such a small minority could accomplish the creation of our country, surely we can take heart about preserving and protecting it. . . .

Prepared Discussion: HOW CAN WE GET ACTION FOR CLEANER AIR THROUGH PUBLIC COMMUNICATIONS?

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I. *INTRODUCTION*

Dean Seldes' remarks on how the mass media may be employed in campaigns to "do something" about air pollution have fairly well covered an approach of considerable importance. It is of importance because it has worked in the past and is relatively inexpensive compared with other techniques which may be more effective but more expensive in time and money when applied. I think Dean Seldes has so well covered what might be called the "public relations" approach to the problem of inducing changes in public opinion and behavior, that I may more profitably spend my time here today talking about some basic social-psychological processes that are involved in political decision making on the community level.

To do something about air pollution is to do something political on the local scene. Local communities and States have to make political decisions—pass ordinances and laws, amend administrative regulations, etc.—and the process by which such changes are accomplished is partly through accomplishing some changes in the public opinion climate of a community and partly through affecting the political elite of a community—those individuals who have more than normal interest and who continually act toward the official decision makers of a local political jurisdiction.

There are many other instances which are analogous to our attempts at changing in a literal sense the atmosphere of a community. Other public health measures, for example, fluoridation or vaccination, bear close resemblances to air pollution campaigns. They all require some action on the part of individuals and at the same time some collective action on the part of the official governmental apparatus of the community. Other types of campaigns also have some relevance for this discussion, for example, campaigns to induce better safety habits in individuals, or to induce greater acceptance for some forthcoming public policy change—perhaps a better public acceptance of bargaining with the Russians.

We can learn a great deal about how to proceed in the case of air pollution campaigns by careful and insightful analyses of similar campaigns addressed to other public issues. This is the purpose of this particular paper.

II. *THE MASS MEDIA AND THEIR FUNCTIONS*

It is difficult not to be impressed with the mass media. Almost everyone reads newspapers; for all practical purposes every home has a radio; and an overwhelming majority of the populace owns television sets. We are all readers, listeners, or viewers of something. And we all know of the remarkable effectiveness of advertising in some types of consumer markets. Yet, there has been among social scientists a growing disillusionment with the efficacy of the mass media. For one thing, media exposure research has brought to light the fact that media fans are selective in their exposure. The editorial pages of local newspapers are hardly read by anyone, while the comics are widely enjoyed and avidly followed by many. Headlines

bered in great detail by the great majority.

Other massive facts have finally been noticed by the social scientists, namely, the poor correlation between the editorial opinions of the media and the political opinions of their aficionados. Roosevelt and his political successes in the face of a hostile press, the abject failure of information campaigns for civil defense, and the like, all have placed the social scientist in a position of great skepticism about the efficacy of the mass media in moving masses of people to new positions on the spectrum of opinion on some types of issues. (Incidentally, this view is not shared by the alarmists and the Madison Avenue specialists who assume that, because breakfast cereal can be sold by the mass media, Richard Nixon can also be sold in the same way.)

It is critically important to examine the types of areas in which the mass media are effective and the types in which their efficacy leaves much to be desired. It is quite easy to affect public opinion concerning the internal affairs of Azerbaydzhan through a saturation campaign in the mass media because for all practical purposes there is no existing public opinion concerning this country. It would be much more difficult to affect public opinion concerning the major western nations because there is some existent public opinion and because for many of the modern western nations there is some sense of identification among the American population. Attacking the Germans attacks to some degree the German-American population, or praising the Germans alienates to some degree those nationality groups whose memories of World War II are stronger than those of others.

Attitudes towards other areas of behavior are difficult to change because these attitudes may become integrally fused with attitudes towards central loyalities of the individual. Thus, a campaign in favor of birth control clinics is bound to arouse resistance among Catholics, even those who employ birth control measures disapproved by the church, because moving in this direction runs counter to their loyalties to a church and ultimately to the family line from which they have descended. Often enough, an issue seemingly neutral in character, as fluoridation appears to be, becomes fused with other issues dividing the community and fluoridation referenda have failed more often than they have succeeded over the past decade despite the heavy sup-

We have to examine air pollution campaigns from the point of view of what kinds of motives and loyalties may be at stake in attempting to move a population and what kinds of functions the mass media may be appropriately employed for.

From an abstract point of view, everyone stands to gain as individuals from cleaning up the atmosphere. Depending on the measures that are emphasized as desirable to enact, some small or large proportion stands to lose something. An industrial plant stands to lose some of its competitive advantage from increased costs; householders may have to employ a higher grade of heating fuel or have to pay higher taxes for the removal of rubbish previously burned in the open. It is not clear offhand that the gains to each individual clearly offset the losses to each and it is clear that, for some individuals, losses clearly offset gains by a great deal. In short, there are existing sources of resistance to air pollution control measures and these sources of resistance may be such as to render impractical the winning over of a majority to the anti-air-pollution side. Dean Seldes is perfectly right in pointing out the analogy between air pollution campaigns and mental health campaigns: everyone is for better mental health and for cleaner air, but it is not clear whether the cost to the individual is offset by the gains in either case.

In such campaigns the mass media have two major functions. First, to a large degree the mass media play to two types of audiences, each defined by the issue in question. Persons vitally concerned with an issue constitute one audience—sometimes the only audience. For example, editorials on tariffs on cotton goods are read by those heavily concerned with the growing of cotton, its manufacture, and its sale in finished forms. The other audience is the general public, whose concern with the issue is only minimal. The mass media can have a very important effect on the former audience without much effect on the latter. Public officials are avid readers and listeners of the media and a particular measure may be put into effect by political decision makers because the media give the appearance of great public agitation over the issue in question. Urban renewal proposals are often of this sort, especially those designed to resurrect the downtown centers of our cities, about which the general population often cares very little.

mass media were used most effectively by a branch of a well-known giant firm in order to obtain support from overall management for its development activities. The manager of the branch managed to get a feature article written in one of the news magazines heralding the forthcoming trend towards widespread use of teaching machines in the schools, a development in which the branch in question was much concerned. Once the article had appeared, the manager was able to go to top management with positive proof of the importance of this new development and managed to obtain the support he needed.

Another important function the media can play is to provide ammunition for the rationalization armament of the individual. Thus, those who believe strongly in air pollution control measures are reinforced in their attitudes by the messages they receive in the mass media. It is important to understand that this is an important function, the means by which the cadres for one side or the other of an issue remain in the ranks, without which the position may deteriorate radically.

III. *SOCIAL CHANGE IN THE LOCAL COMMUNITY*

Before a proposed change in a community can become an object around which public opinion pro or con is formed, it must first come to the attention of the population in question and, second, be given an interpretation which engages the ongoing values and attitudes of the population. There is no public opinion concerning issues which have not received any attention and no evaluation of issues until an interpretation is made of the meaning of such issues for the individual members of the community and for the solitary social groups which compose the community social structure.

An obvious suggestion which flows from the first consideration is to keep a proposed social change from receiving so much attention that it becomes an issue. Thus, we may note that when fluoridation in a community was considered by administrative action it tended to be adopted, while when it went to a referendum it tended to be defeated. The strong temptation to designate an issue as a technical matter to be disposed of by administrative action is a recognition that on some matters it might be best to avoid coming up before the bar of public opinion. Indeed, public school administrators and advocates of this procedure, which they have followed with great success.

Obviously, not all decisions should (or can) be kept from becoming public issues. If you are going to rip out a section of a city for urban redevelopment or require a large proportion of the population to give up burning rubbish out of doors, it is hard to keep such a decision from developing a large interested public. Anti-air-pollution plans for a community or region fall into the category of decisions which require some degree of public attention and consent. Hence the problem for practitioners is how to keep such a plan from activating and engaging the enduring social cleavages in the community and also how to attach to the plan a benign (or even better, a beneficial) interpretation on the part of the major social groupings in the community.

Perhaps the best way to understand how this can be accomplished is to look at several examples of successful introduction of innovations. Some new items of behavior have diffused primarily through the friendship and kinship chains that link together the members of a community. Thus new agricultural methods have this characteristic of diffusing along the lines of existing leadership and friendship in agricultural communities. This is an example of the adoption of an innovation in which the adopters clearly benefit without any corresponding loss to any particular group or individual.

As a more appropriate example, let us consider the successful adoption of an urban renewal plan. Urban renewal plans often involve considerable deprivation to the individuals in an area for the sake of some general overall public interest which is ultimately reflected in the individual's interests in his particular domicile or investment property.

Consensus on a generality that something should be done about an urban area is easy to achieve, just as it is easy to achieve consensus on the idea that cleaner air is better than dirty air. But a specific urban renewal plan is harder to obtain public consent for. Particular properties are to be demolished, particular retail businesses are to be relocated, and land is to be reallocated to other uses. Specific interests have to be subordinated to some overall goal. Yet, in many urban neighborhoods, widespread support is generated for such plans and, where this has been the case, it has been accomplished through making use of the existing structure of the community in committing each major segment of the

community to the overall goals and to the specific details of the plans.

The general point to be made here is that through the use of existing structural features of the community, every major line of potential cleavage is cut across, with the result that the resentment some individuals may feel toward the way in which their particular interests have been handled is never allowed to spread along a fault line in the community and to divide, for example, Negroes from whites, large business from individual homeowners, and the like.

IV. *CONCLUSIONS*

The general point of my remarks here today is that the process of public opinion formation is a group process and that the individual rarely is influenced by the mass media as a single atomized individual. The media have a role to play in supplementing the natural features of community social structure but by themselves alone are relatively powerless to affect major changes in the distribution of loyalties and attitudes in the general population, especially in connection with issues in which each individual has some stake.

HOW CAN WE GET ACTION FOR CLEANER AIR THROUGH — AND AT — ALL LEVELS OF GOVERNMENT?

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Except for the problem of war, there is no problem that presents a sharper challenge to man's capacity to organize and act in behalf of his own survival than that of air pollution. Some might argue the equal gravity of Malthusean implications of the population explosion or of the problem of integrating the vast underprivileged segments of mankind with the more fortunate residents of the 20th century. A case could also be made for the proposition that pollution of land and water could make the planet as uninhabitable for man and those other living things upon which he depends as could air pollution. It takes little imagination, however, to recognize the interconnections among these several possible roads to doom. This reflection points directly to the thesis of this paper: If we are to get the action ultimately needed from all levels of government to clear the air and maintain the atmosphere of this planet as a pleasant, healthful, even possible, environment for human and other creatures as we know them, we must learn how to conduct a massive integrated attack on air pollution. It is a part of this thesis that integration must be on the basis of a hierarchy of regional areas extending at least to the whole globe, if not ultimately to the solar system, and that there must also be integration with respect to many acts that directly and indirectly affect air pollution or the control thereof.

Let me hasten to say that I am in no way qualified to speak as a scientist on the physical and technological aspects of the air pollution problem. It may, therefore, seem inappropriate to pitch a talk with the rather workaday title that this paper bears at so high a target as the postponement, if not the prevention, of the end of man. Prophets of doom have come and gone for thousands of years and the world has gone on. In all soberness and conservatism, however, thoughtful people must in this age begin to face up to the stark fact that we know of nothing inherent in nature that insures the long continuation of the human experiment on earth. Communities, societies, civilizations, have risen, declined, and been blotted out, the destruction in some cases having been induced or hastened by the fecklessness of the people concerned and the inability of their institutions to cope with problems of survival. It is only in the last few years that it has become clear that the follies and incompetences that in times past have spelled the doom of smaller societies could now accomplish the downfall of the society of man. If the danger that inadequately controlled air pollution might be a major, if not the sole, instrument of such downfall is not clear and immediate, we should, I think, take the position that it *is* clear and imminent. This is because we cannot be sure when a point of no return might be reached in atomic pollution or even in other forms of pollution that tend in various ways to upset the balance of nature. And from what I read and hear from people who know more about these things than I do, as well as from what I see and smell and feel, I am convinced that we are at least in danger of postponing effective action to the point when it will take truly heroic efforts and exact an appalling toll to correct or overcome the effects of long neglect.

Now I have an uneasy feeling that the hard approach embodied in the thesis of this paper may seem to some to be in conflict with what I take to

be the mood and thrust of this conference: namely, to get on energetically and confidently with the business of applying our scientific, governmental, and sociological know-how to the clearing of the air. I myself see no such conflict. I did consider the possibility of sketching a case study or two of the politics of intergovernmental action for control of air pollution in some specific multijurisdictional areas. It would be perfectly possible to report, and I am sure others have reported at this conference, on the way in which a combination of scientific, civic, administrative, and political leadership has produced significant improvements in atmospheric conditions in certain areas. Indeed, the next paper that you are about to hear, by John Bodine, president of Penjerdel, lays down the essential ingredients of such regional action. We need this kind of action repeated in many communities that have hardly begun to marshal community resources, public and private, to attack that very large portion of the air pollution problem which must involve primary action by local agencies acting under State authority and in collaboration with State and national agencies.

Despite the fact that certain kinds of air pollution control must begin with, or involve, action by governments at the lowest or most local level, the control of the atmosphere, like the control of the weather, is inherently no more a local problem than the protective tariff. The protective tariff has important local impact and tariff policy is accordingly subject to local political and economic influences and pressures. The control of trade, however, is essentially a national matter. In a way, the situation with respect to air pollution is the reverse of that with respect to the tariff. While controls must be exercised at the very specific local points whence pollution emanates, the effect of the controls or lack of them quickly spreads out over the land far beyond the local jurisdictions through which the police power in our system is generally exercised. This means that if we are to have effective air pollution control, it must be based upon a consensus and upon authority to translate that consensus into action over wide areas that transcend not only municipal but also State and even national boundaries.

Air pollution control is, of course, not the only governmental problem that has overrun ancient boundary lines in this increasingly urban-technological age. It is, however, one of the most obvious and I believe, in a very basic sense, one of the most urgent and compelling of those problems. This constitutes a rather special reason why I believe that persons who have had the vision to become personally involved in the crusade for cleaner air have the obligation to concentrate on the problem of developing the necessary consensus to increase the involvement of the higher levels of government with their broad reach and extensive resources. It may surprise some who have borne the brunt of an uphill battle for years, but I would suggest that the issue of air pollution control may have great strategic value in the larger effort which must be made to refit public decision making and action on a variety of problems to the fact of interdependence—metropolitan, national, international. To the extent that action initiated at the local level succeeds in reducing air pollution, it is all to the good. Perhaps even more important, however, is the demonstration, through local initiative, of the inadequacy of such action unless it is set in a larger framework of regional, State, and national legislation and action. This demonstration can thus help build the case for the only kind of all-out action for cleaner air through all levels of government that is really worthy of the great efforts that are symbolized by this conference. At the same time it will contribute significantly to the modernization of our whole system of government.

It seems hardly necessary to recite the reasons why the control of air pollution needs to have as broad a base as all the outdoors through which contamination from any one source can move. It is very well for a single city or group of communities to reduce their own pollution of the air but if a neighbor continues to pour noxious substances into a wind blowing their way, the payoff for the self-denial and self-control may seem hardly worth the cost. Yet it may be quite unreasonable or impossible to expect the neighbor to stop polluting the air on its own if that neighbor happens to be in a weak competitive position economically or in the capacity of its civic and political leadership. Theoretically, if everybody agreed that air pollution must be stopped to the extent that it is technically feasible to stop it, the thousands of local governments that would be required to adopt and enforce uniform controls might solve a major part of the problem. However, all experience is against the theory that any such result could be achieved in such fashion. The less advantaged, the weaker, or the less conscientious units are almost certain to feel either that they cannot, or cannot be expected

to, forego the luxury of the shortrun gains of inaction. The existing impasse with respect to atmospheric testing of nuclear devices is instructive on this point. Despite the confusion of scientific tongues on the subject, no one denies that in the long run the releasing of radioactive material in the atmosphere is bad and could be extremely dangerous. Yet the certainty that this is so over the long run has not yet persuaded the great powers that it is imperative that they forego the immediate competitive advantages in the arms race that result from continued testing.

This points to one of the prerequisites to any effective political action for air pollution control at any level, namely, information—information that is as fully buttressed by scientific evidence as possible and clearly and convincingly conveyed both to the general public and to key policymakers. And in view of the gravity of the problem or of the many problems involved in air pollution, this points to a very great obligation on the part of National and State governments to see that more resources, fiscal and personal, are invested in research and education. We simply have not begun to match our investment in the development of new products and new processes to an appropriate extent with investment in the study and control of the dangerous byproducts which the development of new areas of technology produces. In general, only State and national governments have the combination of resources and power required either to provide the money or to mandate the expenditures which are necessary.

But research and dissemination of information are only the beginning of the responsibilities of State and national governments. In our Federal system, the States have the basic responsibility for the structure and powers of local governments, for the general maintenance of law and order, for the regulation of the conduct of people in the individual and corporate capacities, and for the regulation of the use of the land and of the resources related to it.

In many States both constitutional revision and statutory changes are needed in order to gear the State and its creatures, counties, municipalities, and other local governments, to the needs of government in the metropolitan age. States have hobbled themselves and their local units by constitutional or other legal restrictions, the net effect of which is to prevent either the State or individual local governments from taking needed action. Ancient systems of local government are frozen into the law, so as to prevent areawide action on problems like air pollution that simply will not confine themselves within existing boundary lines. People interested in action for cleaner air through all levels of government should, therefore, investigate the constitutional and other legal inhibitions against effective State and local action and associate themselves with every effort to reduce or eliminate them.

One of the most hopeful developments in recent years looking toward the reinvigorating of State and local governments for service in an increasingly urban society is the work of the Advisory Commission on Intergovernmental Relations. This Commission has issued a number of reports that should be of interest to students of air pollution control, including especially a report dated July 1961 entitled "Governmental Structure, Organization, and Planning in Metropolitan Areas . . . Suggested Action by Local, State, and National Governments." The report includes a number of specific and practical suggestions for changes in State laws and constitutions designed to facilitate metropoliswide action on problems that have outgrown municipal and county lines and to enable the State to provide more assistance and guidance in the development of local institutions appropriate to modern times. The revelance of such proposals as these to air pollution controls is suggested indirectly by the following sentence from a paper by Sidney Edelman entitled "Legal Problems of Inter-Jurisdictional Air Pollution Control," presented at the 55th annual meeting of the Air Pollution Control Association, Chicago, May 24, 1962: "The creation of special-purpose air pollution control districts, while a useful method of overcoming the limitations of territorial jurisdiction, should, however, be considered as a step toward a comprehensive scheme for more effective government within a metropolitan area."

In the long run, it is good politics for persons interested in this and other phases of environmental health to make common cause with persons interested in modernizing our governmental machinery for the purpose of facilitating the performance of other vital public services. Another equally important, if not more important, reason for such collaboration is the fact that, as Mr. Edelman suggested, effective air pollution control depends directly upon the use of such governmental powers as "city planning, traffic planning, zoning, and land use planning." Obviously, such powers, plus the power to raise and spend money,

which is essential to all other governmental activities, cannot be effectively exercised if too many vital government functions are set up in a host of disparate special districts, authorities, or agencies. Air pollution control may also be affected by many other governmental activities, including the way in which various units of government provide for or regulate the disposal of wastes, and the way in which open spaces are handled and what is done about the conservation or replacement of trees and other vegetation. I take it that Dr. Chauncey D. Leake, Assistant Dean of the College of Medicine, Ohio State University, speaking on the "Social Aspects of Air Pollution" at the November 1958 Conference on Air Pollution, was in earnest when he suggested that "Maybe 10 trees planted for every automobile, with 100 for every truck, would help" to keep down the increase in the blanket of carbon dioxide which threatens to make drastic and very uncomfortable changes in our climate and the distribution of water over the globe. Of course, as Dr. Leake suggested, such tree planting by cities would benefit them regardless of the possible effect "in reducing the contamination of the air we breathe."

The very mention of the possible longrange concern of mankind over the mounting pollution resulting from the general increase in the burning of hydrocarbons throughout the world, including the burning of them in fast-moving jetplanes and other longrange vehicles, simply underscores the necessity for acceptance of the ultimate responsibility for conservation of the air we breathe at the highest possible levels of public decision making. National governments should make more use of their own authority within their own jurisdictions and, by international regional and worldwide agreements, perhaps involving the United Nations itself, should seek to develop a worldwide conscience and policy with respect to certain aspects of the problem. Is it too fanciful to suggest that, in this era of instantaneous global communication and almost comparably rapid global travel and transportation, it may be easier to develop, at least among the most highly industrialized and urbanized nations, something like a consensus on the global concern for clean air than it is to get agreement among local public and private interests in a limited area on the abatement of local sources of air pollution?

We Americans are attached to the theory that virtually all good things in government and public policy arise from the local community, where presumably understanding and agreement can most readily be had, and gradually affect action at the more "remote" State and national capitals. This undoubtedly is still true of many areas of public concern and action but I hope I will not be regarded as un-American for suggesting that it has never been true with respect to all areas and that, in this age, it is most emphatically not true at all with respect to some very important matters, including the matter of air pollution, which is our immediate concern. It has often been observed in recent years that the development of mass media of communication has contributed to the tendency of many citizens to pay more attention to and feel more at home with national politics and national issues than they often do with respect to local or State issues. I suggest that this tendency, disheartening as it may be to some people, should be exploited by proponents of all-out action through all levels of government for cleaner air. People may well accept the argument propounded by locally based public and private interests that certain inconveniences and discomforts, even dangers, resulting from air pollution must be suffered in the interest of progress and prosperity. Indeed, people have been accepting and acting on this argument for a great many years, comforting themselves with the thought that sooner or later they might be able to afford to move away from the nuisance, leaving those who have not yet qualified by the virtue of success to continue to suffer the purgatory of smoke, smog, and stench. Much can be said for this point of view. On the other hand, unless people are going to be utterly callous about the possibility that their not too remote descendants may not be able to enjoy this fair earth if something is not done on a worldwide scale to preserve our air for them to breathe, they may respond more readily to a national program of air pollution control which appears to be commensurate with the greatness of the problem and the grand objective to be served by solving it. And the same people who might argue that it is unfair to expect a local community to jeopardize its competitive position economically by cleaning up its own air at its own expense might well become supporters of a national program which distributed more equitably the costs and benefits of effective control.

Conceding the need for more vigorous State and national action in this area is not to accept sur-

render of local responsibility. In fact, as in the case of various other national programs, it may tend to strengthen local responsibility by making it feasible for local governments to participate in an effective program. We have in the last few years seen a number of governmental activities that had previously been regarded as strictly local, for example, welfare, formerly known as "poor relief," which have become accepted as matters of major State and national concern. A result has been that the local functions in the field of welfare are now greater and more important than ever. Air pollution control is simply another field in which it may be much more effective to attempt to supply water to the roots of the tree of self-government by letting it rain down from above rather than by depending upon its rising through a hard crust of local indifference or antagonism.

Air pollution is an old problem that has engaged the attention of ingenious minds for many years. It would be a comfort if we could attack it in its modern guise in the spirit in which John Evelyn took out after "The Inconveniency of the Smoke of London" in a delightful tract published "by his majesties command" in 1661 and directed "to his sacred majestie, and to the parliament now assembled." The tract was entitled "Fumifugium," which I take it might be freely translated as "Smoke, smoke, go away." Evelyn delivered a horrendous indictment against the smoke of London, which he described as "That Hellish and Dismall Cloud of Sea-coale." As a result of the smoke belching forth from the establishments of "Brewers, Diers, Lime-burners, Salt and Sope-boylers" and some other private trades, Evelyn reported that "The City of London resembles the face Rather of Mount Aetna, the Court of Vulcan, Stromboli, or the Suburbs of Hell than an Assembly of Rational Creatures and the Imperial seat of our Incomparable Monarch." Indeed, he suggested that "The weary Traveller at many miles distance sooner smells than sees the City to which he repairs." The author further discoursed on the malignant effects of the smoke on the health and the appearance of the people and upon fruits and flowers. He particularly bemoaned the effect upon "the Hands and Faces and Linnen of our Fair Ladies and Nicer Dames . . ." And how were these evils to be cured? By two simple expedients: first by an act of Parliament requiring the offending industries to move a sufficient distance out of the city and by the charming expedient of surrounding the city with plantations of sweet-smelling flowers and herbs. One who has visited London in more recent times will not be surprised to learn that Parliament did not pass John Evelyn's proposed act, although it is recorded that Evelyn was instrumental in bringing about the planting of trees and ornamental shrubs in the London area.

As we have already indicated, the latter type of action may still make more sense than some of Evelyn's contemporaries may have supposed, as a hedge against the poisoning of the atmosphere. The first remedy, that of moving noisome industries out of town, is, perhaps fortunately, no longer a satisfactory remedy for the basic evils of air pollution. This is partly because of the spreading of our urban population on the land, partly because of the continuing increase in the sources of pollution, and partly because we have learned that the worst effects of such pollution may extend much farther than the visible and odorous effects of the smokes of Evelyn's day.

It is, therefore, incumbent upon us to devise public policies for cleaner air in the light of conditions which have developed over the 300 years since John Evelyn wrote his tract and to engage all levels of government in an effort of a magnitude and complexity commensurate with the infinitely larger and more complex system in which we live today.

Prepared Discussion: HOW CAN WE GET A(FOR CLEANER AIR THROUGH—AND A' LEVELS OF GOVERNME

RONALD BROOKS CAMERO
U.S. Congressman-Elec
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When Director Bebout cited excerpts from John Evelyn's prosaic tract on London's 17th-century air pollution problems, a picture which appeared only last week on the front page of a Los Angeles newspaper popped into mind.

The photo, snapped in Mr. Evelyn's beloved but still beclouded city, showed a young lady feeding pigeons. Now there is nothing objectionable about feeding pigeons, but it's carrying things a little too far when, in order to be a birdlover, one has to go about wearing a mask of the type used by hospital personnel who treat persons with communicable diseases. Not that the pigeons were diseased, mind you, it was the London air which prompted the young lady's precautionary measures.

Mr. Evelyn—in heaven or wherever it is that 17th-century clean air crusaders were sent to reap their final reward—is probably now preparing another tract on this important topic, and leveling another blast at his nation's Parliamentarians.

Being a legislator, I must in all fairness say that those parliamentarians certainly had a dragon by the tail when they tangled with "The Inconveniency of the Smoke of London."

For today—300 years later—we at this National Conference on Air Pollution are tangling with an American dragon of similar species.

The smoke he belches is much filthier and more dangerous than that of his 17th-century ancestor. His breath is also a good deal fouler—despite some of Dean Seldes' friends in the communications field assuring us that he has 29 percent fewer cavities.

My special interest in air pollution is as a relative newcomer and reflects what I hope are sound judgments from both my business and political experience. For many years the local jurisdictions in California have been most effective in developing local ordinances to cope with the stationary sources of pollution. Under the able direction of S. Smith Griswold in Los Angeles, and with the cooperation of the press, an aroused public, and a determined board of supervisors, we have dedicated tremendous resources to the abatement of contaminants in the air.

Four years ago, as a member of the Public Health Committee of the California Legislature, I was convinced by the scientists—many of whom are presenting papers at this conference—that we had reached the point of diminishing returns with respect to eliminating stationary sources of pollutants. Also, as a businessman attempting to return a profit on investment, I had come to the same conclusion. I could then construct a hot-mix asphalt plant for about $250,000—and of that amount between $50,000 and $75,000 were devoted to air pollution control devices; in addition, I had to use high-priced natural gas instead of fuel oil for heating purposes.

We in Los Angeles were convinced that our only major uncontrolled source of pollution was the automobile. Four years later this is still true and certainly calls for concurrence in Director Bebout's comments concerning the obsolescence of geographic boundaries in this increasingly urban-technological age.

There can be no question that ours is a highly mobile society, a population constantly moving on wheels. Cars cross city, county, and State boundaries with the same abandon as ants holding a picnic on a patchwork quilt.

This presents a major problem to legislators at all levels of government. For we must not lose sight of the fact that lawmakers function in a political atmosphere—an atmosphere which, unlike the air we breathe, does frequently have sharply defined geographic boundaries.

Previous speakers have dealt with the commendable but thwarted efforts to properly combat air pollution on a regional basis. To the extent that the sources of pollution are stationary the only answer that I have for the afflicted is perseverance. The technical information on source and method of control is readily available. It is merely up to each community to recognize its problem and go about solving it with the knowledge at hand.

But what of the nonstationary sources—of the ambient nature of air and the vast distances involved? I traveled Sunday from Los Angeles to Washington, D.C., in less time than it took Mr. Evelyn's parliamentarians to travel from Soho to Land's End in their day. In the 1600's these distances prevented a representative from the Soho district from convincing a delegate from Land's End that a joint effort was required to remove the inconvenience of London's smoke. Today this distance still works against local government jurisdictions.

How does the mayor of West Covina, Calif.—a community which has more two-car families than any other city in America—convince a mayor from Twin Pines, Maine, that both should join in an effort to require that all automobiles meet certain air pollution standards? Again, the answer is that he doesn't and he can't.

The only legislative arena in which auto air pollution can be combated on a national scale is the Congress. Even here, the problem of securing legislation which would require automakers to manufacture products that meet certain standards is not an easy one. Nor will it be easy to adopt suitable standards.

From my experience as the author of the legislation creating the California Motor Vehicle Pollution Control Board, I know full well the indifference of residents of certain geographic areas and political jurisdictions, even in California, to the gravity of this problem.

The fact that we are assembled at this conference today under the auspices of the Public Health Service, and the fact that participants in this conference represent all geographic areas of this country and most of the States, lend credence to my thought that the Congress is the legislative arena that can bring the sharpest focus on this "organizational effort for survival of man."

As a freshman Congressman—or rather a Congressman-elect who has not as yet been given any committee assignments—it would be impertinent for me to set forth a program to accomplish what I believe to be the obvious objective. I can say that the progress made in California with respect to auto contamination has been like pulling teeth.

The electorate and especially its representatives of rural areas show complete indifference. Technological information develops so rapidly that it renders obsolete tomorrow what we accomplish today. Headline seekers confuse the public with rash claims, auto manufacturers point the finger at oil companies, oil companies at chemical companies, and all three at the politician. Thus the electorate becomes indifferent as a result of conflicting claims and of having lived under the Sword of Damocles for the last quarter century—death is imminent from "the bomb," "test radiation," cigarette-induced "cancer," "air pollution," and general mayhem on the highway.

All of these things have made it difficult for the politician to keep an eye on the objective while, in the words of Theodore Roosevelt, "keeping an eye on the crowd to see if they are being led where they want to go."

Despite these handicaps, we in California have hammered at a program that holds great promise. Though I have not seen the papers presented in Panel A that deal with the automobile, I am confident that they reflect a recognition of this accomplishment and a plea for a concentrated national effort on behalf of all concerned individuals. Certainly when we can orbit men around the earth, can see and hear instantaneously happenings halfway around the world, can destroy the earth by punching a button, we can—if we decide to—devise ways to control carbon monoxide, oxides of nitrogen, and olefins in internal combustion engines.

Together we can educate our Senators and Congressmen that this threat is imminent—and I believe this is the proper area, for the Congress has a sharper awareness of national problems. Daily, coalitions are formed and compromises ham-

mered out as men from north, east, south, and west focus on various legislative goals.

There is no reason to believe that air pollution control relative to new vehicles cannot become one of these goals. We must never be deluded into thinking that the constructive Congressman of 1963 is on a par with the provincial parliamentarian of 1663.

And, being an optimistic birdlover, I'm confident that future generations of Americans will not have to go about with masks as they feed their beloved pigeons.

HOW CAN WE GET ACTION FOR CLEANER AIR THROUGH COMMUNITY ACTION?

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I welcome the opportunity to make a statement on how we can get cleaner air through community action. The right of Americans to tackle an important public problem in our capacity as concerned citizens, individually and in private groups of our own choosing, is one of our cherished privileges.

Any realistic examination of community action as a means to get cleaner air should begin with an analysis of the impediments to such action. Only when we have some idea of the aspects of the air pollution problem which make community action difficult shall we be able to clarify our ideas as to how community action can be made more effective.

To my mind there are four principal impediments to community action on this problem.

The first is the fact that in many of our communities the public damage suffered from air pollution is obscure and unrecognized. Of course this is not true of all of our communities. In some of them air pollution is a frequent and obvious source of irritation and even more serious health hazards, and in these and other communities the public is quite aware of other damaging consequences. But I submit that all of us interested in community attitudes on this question must recognize that in many communities our people are not aware that they may be inhaling substances which may eventually cause cancer of the lungs; they do not associate a bad cough with atmospheric conditions; and it may be only on days of particular wind direction that a housewife will be bothered by flyash on her clothesline. Related to this lack of awareness there is often a degree of civic apathy; the offensive odors from some industries, or the haze that obscures an otherwise beautiful day, are accepted as features of urban living about which nothing can be done.

A second important impediment to community action, no doubt related to the first, is the difficulty of communicating to the public the thinking in this field of our scientists and technicians. I do not believe that the scientists are really to blame for this; indeed, I believe that the difficulty largely inheres in the present state of scientific knowledge and in the nature of the scientific process itself, for which our scientists should be complimented rather than criticized. The fact remains, however, that much scientific knowledge in this field is still in the stage of hypothesis rather than demonstration, and that a great deal of work remains to be done to make the necessary connections in our knowledge: to connect particular substances in the air with particular sources of emission. And in many areas our technology has not progressed to the point of designing methods of control at a cost commensurate with the benefits to be obtained. In addition therefore to the familiar difficulties of interpreting technical scientific information to the public, we have in this field the additional problem that many of our scientists are justifiably uncertain as to their conclusions; and yet it is difficult to arouse citizen concern for a "perhaps."

A third important impediment to community action in this field is the prevalent confusion over values. Everyone would agree that substances impairing human health, and certainly those presenting a threat to human life, should be controlled. But what price are we to pay for reducing odors,

or irritants, or mere lack of visibility? Are factories, or powerplants, or cement works, or oil refineries more valuable to a community than freedom from their effluents? Perhaps these and similar questions will be with us for many years to come, and no doubt each community will have to answer these questions for itself; but on many issues in this field, some community consensus on these questions of value is a prerequisite to effective community action.

A final impediment to community action is the lack of congruence in many communities between our governmental and civic patterns and the dimensions of the air pollution problem affecting that community. For purposes of this discussion I leave to one side the air pollution problems which are international in scope, such as the possibility that further emissions of carbon dioxide may alter the climate of our planet or the level of our oceans; and I also leave to one side problems that arise in a nationwide setting, such as the possibility that a plant subjected to rigid control in one community may move to another part of the country which has less sophisticated regulations. For present purposes I am referring to the air pollution problems of our large urban areas—those continuous built-up areas that attract increasingly larger percentages of our country's population. Most of these areas cover more than one local governmental jurisdiction. Some of them, such as the Bay Area in California, cover several counties and numerous local governments, although all in one State; and some of these areas, which I will refer to as the complex metropolitan areas, cover parts of two and sometimes three States and hundreds of local jurisdictions. The metropolitan region around Philadelphia, for example, extends in a continuous built-up area from above Trenton, N.J., to below Wilmington, Del., and includes 11 counties and no less than 377 local governments. Not only is the power and responsibility of government in such a complex region divided by these numerous governmental boundaries, but the pattern of civic activity is also similarly divided. The larger cities typically have a variety of citizen organizations organized on a citywide basis, but because of the pressing needs of their own cities and for other similar reasons such agencies in one city seldom make a practice of cooperating with those in another. Further, in whose purposes are sufficiently generalized to permit a ready concern with the problems of air pollution, and such organizations in one county often find it difficult to cooperate with those in another county, especially when such cooperation would be across State boundaries. And yet, as all of us know, the wind carries pollutants throughout such a complex region, without any regard to governmental and civic boundaries; and the organization of a community effort to deal with these problems must therefore be on a regionwide basis. Yet the organization of such an effort faces formidable difficulties. In a complex metropolitan region such as the one around Philadelphia, there is only limited public realization of the fact that the region in fact constitutes one community, and that pollution control programs in one city, or even in one State, cannot be fully effective unless similar programs are in operation in nearby communities, including those across State boundaries. If the regionwide community is to mobilize citizen concern for a regionwide program, there must be not only awareness of the need for such a program, but there must be also cooperation in all parts of the region in supporting citizen activity. Yet in many such complex regions there is so far no habit or practice of such regionwide cooperation, and the emergence of such cooperation on any issue is inhibited by the familiar factors of differences between jurisdictions—in politics, in bargaining power, and often in attitudes toward community values.

These then are the principal impediments to community action: lack of public awareness of the problem; our inability at this stage to communicate conclusive scientific findings of cause and effect; our lack of consensus on costs and benefits, on the resolution of conflicts between values; and finally the fractionation of governmental and civic responsibility in many areas, especially the complex metropolitan areas.

Now in the light of these difficulties, what can we do to arouse citizen concern for this problem and thereby to get community action? I suggest that there are four lines of attack which should be taken into consideration.

First, we must press forward with all possible speed and with all possible resources to increase the clarity and definiteness of our knowledge—on what damage is caused by which pollutants, on

from, and on how we can reduce or stop their emission into the atmosphere. There is, of course, much dependable information now available on these points and there is an impressive record of community action, especially in some areas where the connection between observable damage and sources of emission can be suitably demonstrated. But in general the effectiveness and scope of community action will vary directly with our ability to put together a clear and definite story, backed up by competent scientific investigation of the factors bearing on this problem and their interconnection.

The third step which I believe is required for an effective program of community action is to encourage public discussion of the value conflicts involved in this subject. As I said before, each community must decide these issues for itself; and in some aspects—for example, where human health is demonstrably threatened—it may be comparatively easy to arrive at a decision. But there will be other instances where a heavy price in reducing economic potential must apparently be paid for limited gains in convenience or amenities, and where it may be correspondingly difficult to arrive at a consensus. The point is that such issues should not be swept under the rug; they should be subjected to the vigorous testing of intelligent public discussion. The decisions reached in this way, and carried into effect in a program of community action, will make that program more consistent with known community attitudes and therefore much more likely to succeed.

The fourth aspect of an effective program of community action on this issue is the mobilization of all elements in the community to work on it. The issue is an extremely broad one, affecting all members of the community; and when the drivers of automobiles are included among the emitters of pollutants, a very large proportion of the total population must be counted in that role as well. This breadth of involvement justifies a claim for a corresponding breadth of civic interest. The masthead of the Louisville study, for example, shows the participation of local, State, and Federal Government agencies, of business leaders and the chamber of commerce, of newspapers and radio and television stations, of civic and fraternal organizations, and of private citizens who permitted observation equipment to be installed on their property. Acknowledgment is even made of real help given by firemen and postmen in making observations. If we are really to get community action for cleaner air, we must dramatize the fact that all members of the community are affected, that great numbers of them participate in some of the causation, and that only a correspondingly wide mobilization of community resources will suffice for effective community action.

The moral of this is, of course, that we shall need to continue and to strengthen our present programs of research, governmental and private. I realize that the position is somewhat circular, in that the results of research are needed to arouse citizen concern, while at the same time there may be greater interest in the Congress, for example, to vote substantial support for research if there is more widespread citizen interest in such a program. Yet there is sufficient evidence already of threats to human health, and of damage to property and crops, to justify firm support for efforts to extend and clarify our knowledge. Private resources for research must also be involved in this; and in those, no doubt, exceptional situations where private knowledge bearing significantly on these problems has not been made public, consideration should be given to the desirability of compulsory processes for putting that knowledge into the public domain.

Second, we must do all in our power to improve communication in this field—to see that such scientific knowledge as we have is widely disseminated, and in a form that can be understood by the man in the street. Only when there is a widespread comprehension of the damaging effects of air pollution on human health, on property, and on living conditions generally, can we expect to get more effective community action. The various levels of government undoubtedly have a responsibility in this matter of disseminating accurate information; and I feel that we should all be deeply appreciative of the efforts of the Public Health Service in conducting this National Conference, because of the marked stimulus which it is bound to give to wider understanding of these problems. But we should also seek out ways to increase the interest of the mass media in getting out information on this vital subject, and we should explore much more comprehensively than seems to have been done in the past the possibility of getting reliable information about air pollution into the curricula of our schools. To my mind there is no reason why a school hygiene course should not include appropriate information about the hazards presented by air pollutants and the known means of controlling them.

Finally, permit me to say a few words about the special problems of getting community action in complex metropolitan areas. They will need the same things already mentioned: more extensive scientific knowledge; better communication of the facts about air pollution; a continuing community dialog to resolve the questions of values presented by this problem; and a civic effort embracing all interests in the community. But in the complex metropolitan regions, the last two needs present special difficulties.

With regard to questions of values, I said that each community must decide these issues for itself; but the community making these decisions must be one whose boundaries coincide with the dimensions of its air pollution problem. In other words, in a metropolitan region, where pollution from one part of the region can readily affect people and property in other parts of the region, the dialog about values must be regionwide. And yet this is particularly difficult to accomplish in the present state of governmental and civic organization for such regions. For example, in the complex region around Philadelphia, there is as yet no general-purpose regional planning agency to give governmental leadership to the discussion of alternative ways of developing the region. And we are also only in the early stages of developing a regional citizen activity which could assist in arousing public discussion about these conflicting values.

Similarly, with regard to the necessary breadth of citizen involvement, this is hard enough to evoke in a cohesive, centralized community; but it presents special difficulties in a complex metropolitan area. In such a setting it is necessary to work out not only a wide and varied civic approach, but the effort must also be broad based geographically. For example, nothing will have less chance of success in the typical large metropolitan area than a civic effort manned exclusively by the leaders of the downtown community in the central city. This would be the surest way to deter the increasingly important outlying areas from playing their full part.

In view of the special difficulties on matters of this sort in complex metropolitan regions, perhaps I may be permitted to describe somewhat more fully the manner in which we have attempted to work out a community program in the region that extends from Trenton to Wilmington. From many points of view this region ranks second only to the New York City region in complexity. Its population of above 5 million people may be less than the Chicago and Los Angeles metropolitan areas, but few regions, apart from that surrounding New York City, have a greater multiplicity of governments, inasmuch as the region surrounding Philadelphia consists of 11 counties in parts of three States and includes almost 400 incorporated local governments, not counting school districts or special-purpose authorities. While the Delaware River Basin now has an effective interstate commission to work on regional water problems, and while most of the region is involved in a massive transportation study, we have as yet no regional planning commission. In this situation many observers have concluded that one of our important needs is a greater realization by public-spirited citizens throughout the region of the regional or interjurisdictional character of many of the problems confronting their neighborhoods. Accordingly, with the help of the colleges and universities of the region, and of about 100 citizen organizations of many different kinds in all parts of our area, and with financial assistance generously provided by the Ford Foundation, the organization we know as Penjerdel has been created. This organization is nongovernmental; a majority of its board of directors neither live nor work in Philadelphia; and it has deliberately tried to include representatives from all walks of life and from all of our geographical areas. And partly because there was no way of telling which interjurisdictional issue would serve most readily as a rallying point for citizen concern, and partly because it was thought that a broad program might be more successful than a narrow one, the founders of Penjerdel did not choose any one interjurisdictional issue, such as air pollution, for their program, but left the organization free to concern itself with this or other issues as opportunities and interest arose. Penjerdel's method is to encourge research and factfinding on topics of regional concern, and to carry on a varied program of public information about these questions. To strengthen the machinery for community action on a scale broader than the neighborhood, Penjerdel has assisted in the formation of several new countywide citizen organizations, with programs broad enough to encompass concern for air pollution, as well as transportation, preservation of open space, trash disposal, regional planning, and other interjurisdictional questions. These organizations are definitely not oriented toward the central cities of our region. And while

Penjerdel is nongovernmental, it has helped to establish the Regional Conference of Elected Officials as a place where representatives of local governments can meet to discuss their common problems. The membership of the conference is open to the chief elected official of each county and local government in the region. The conference has advisory powers only, but it can encourage studies into regional questions and identify areas of agreement.

Penjerdel has so far sponsored no substantive research in the field of air pollution, but it has made a grant to Dr. Francis Davis at the Drexel Institute of Technology to design research projects that are not now underway which should be undertaken in our area, in hopes that when designed these projects may attract funds from sources other than Penjerdel with which they can be carried out. The regional conference has expressed its interest in these studies and has asked that the research team keep the conference informed of its progress.

In other words, Penjerdel's plan for community action in a complex metropolitan area is to establish a regionwide focus of citizen interest; to sponsor research into the air pollution problems of the region; to use all available means of publicity to disseminate information about these problems; to arouse the interest of elected officials throughout the region; and to encourage the vitality of citizen organizations of sufficiently broad geographical base and program content so that they will be in a position to stimulate public concern for a problem that in our area flows freely across a large number of governmental boundaries.

This is our program for eventually getting community action in our complex metropolitan area. I would not claim that it would either be necessary, or even appropriate, to the situation in many other communities. But it seeks to provide a vehicle by which all interests in the community can play their part in tackling a regional problem such as air pollution. For after all, the cardinal rule in getting community action on air pollution is to remember that this problem is everybody's business. As Benjamin Linsky has said, "Air pollution is everyone's business because almost everyone in a community adds to it, everyone in a community is affected by it, and almost everyone must be involved in backing up a program for control."

Prepared Discussion: HOW CAN WE GET ACTION FOR CLEANER AIR THROUGH COMMUNITY ACTION?

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When I first talked to Mr. Bodine concerning the general nature of his paper, he told me that he considered himself quite a newcomer on the subject of air pollution. He said, however, that the major interest of Penjerdel in solving common problems through community action had very quickly brought him face to face with the problem of air pollution control and that this now was a most important item in Penjerdel's interstate activities. Having now had the advantage of reading his paper, I can only conclude that for a man who claims to know little about air pollution, he has certainly learned very quickly. His outlining of the problem, the difficulties of solution, and the importance of cooperative efforts is a remarkably fine job. As to most that he has to say, I can only add "amen." There are, however, some points on which I should like to comment further and some ideas that have occurred to me through rather long association with air pollution control matters, particularly from the community relations point of view.

For a number of years I have been particularly interested in the use of the term "community." Although from a dictionary standpoint it has a number of connotations, for the most part they all stem back to the fact that a community is a body of people having common organization or common interests. I can think of few things that should bind so many people together in common interest as a common concern for the purity of our most essential natural resource—the air we breathe.

It is true that smoke and other types of air pollution, according to the historians, have been a matter of concern for centuries, but it is only in relatively recent years that the matter of control has become a subject for major consideration. One need only follow the press reports to see how this subject has grown in importance during the past 15 or 20 years. Although most of us who are close to the problem are convinced that the subject is still not receiving the attention it should, we should be encouraged when we compare the coverage today with that of only a few years ago.

Mr. Bodine speaks feelingly about the general apathy of people when it comes to the subject of air pollution. I am well aware that this exists, but also aware of the fact that on most subjects of major public importance there are relatively few people who take a lively personal interest in them. It is only when the dangers become apparent in the personal affairs of a large number of people that any sort of mass participation occurs.

I feel very strongly, however, that due to the progress being made by the Public Health Service and the various interested groups in the control field and in industry, we have now reached the stage at which the majority of those who are considered thought leaders agree that air pollution has become a matter of serious concern to the country and that, unless strong progressive measures are taken, the situation can become much more serious than is now apparent.

It has been a matter of record in this country that when a problem becomes severe enough to be threatening, people throw aside their differences and rally behind a common objective. I believe we are fast approaching this point. There are

fewer and fewer differences of opinion on the dangers inherent in increased urbanization, industrialization, and automotive transportation. In my travels throughout this country and to some extent abroad, I certainly find very little shrugging of shoulders and the "so what?" attitude that was very much in evidence not too long ago. There remains a considerable difference of opinion about the exact effects of air pollution on health and general welfare and also about the relative contributions from various sources. For the most part, and of course there are exceptions, industry is well aware of its contributions to air pollution and of the necessity for positive preventive measures. There are very few control agencies which claim to be experiencing a major lack of cooperation from members of the industrial and business community. In other words, although 10 years ago control officials and representatives of industry were more often than not looked upon as adversaries, they are now for the most part considered to be fellow campaigners in a common battle.

Mr. Bodine emphasizes the importance of getting information on air pollution to more and more people, particularly through the various organizations to which they belong and through the schools. He is absolutely right on this. Even though our various public health and research groups have been making much progress (in spite of the often unfair criticism by those who think the progress is distressingly slow), it is still easy to see how the public can become confused.

With so many new developments and dramatic advances in technology, there are continuous changes in the nature and magnitude of pollutants which enter the atmosphere. Not too long ago, the metallurgical and chemical plants were considered the major offenders. As they began to take care of their obvious deficiencies, the powerplants, the refineries, and the open burning of refuse became major culprits, followed by incinerators and more recently, of course, the automobile. Also, for many years, the concentration was on cinders, flyash, and other particulate matter. Then, as these began to be cleaned up, the emphasis swung towards sulfur dioxide (SO_2) and other gaseous discharges, to which was added later the discovery of the effect of sunlight, etc., on the chemical composition of pollutants. It is easy to see how the layman is inclined to wonder just who bears the responsibility for polluted air and just what the dangerous pollutants may be. All too often, people don't realize the considerable extent to which they themselves contribute to the problem.

As I have said before, I firmly believe that control officials and industry are making great progress towards working hand in hand in solving their mutual problems. I know from firsthand experience that not long ago it was considered improper for public officials to say anything very nice about the efforts of utility companies and other industries. In fairness, I must also admit that in all too many cases the criticisms by the public officials were justifiable. I now find that with the establishment of definite control programs and careful attention to a meeting of schedules, the efforts of these cooperating industries are appreciated. Furthermore, the officials are not afraid to say so, even though, quite understandably, they will never admit that as good a job is being done as they would wish.

In the dissemination of information on air pollution control, the Air Pollution Control Association, in my opinion, does a particularly good job. As the membership in this Association increases and more and more people partake actively in its program, an even better job will be done. I am particularly interested in the expanding activities of the local sections of the Association. I happen to be the present Chairman of the Executive Committee of the Mid-Atlantic States Section, which holds technical conferences twice a year, as do other sections throughout the country. This allows for local participation by those who are not always able to get together at the national meetings or get to a conference such as this one.

One of APCA's activities is the promotion of Cleaner Air Week, held each year in October and which has been supported by the President of the United States and various governors and municipal officials. This activity has also been highly commended by our new Secretary of Health, Education, and Welfare, the Honorable Anthony J. Celebrezze.

The Air Pollution Control Association has broadened the scope of its membership throughout the years and we now find representatives of almost all industries and educational institutions as well as various civic groups. In addition to this, of course, there are the national, State, and municipal control officials who were largely instrumental in its formation as the Smoke Abatement Society more than fifty years ago. For many years the constitution and bylaws of the organization speci-

fied that the President must always be a control official, and there seemed in the operations of the Association other considerations that downgraded the industrial representation. These provisions have since been altered and industry is now considered a member in perfectly good standing and its representatives can even aspire to the presidency of the organization.

I spoke a few minutes ago about our new Secretary Celebrezze, which reminds me of my experiences some years ago in this air pollution field. In 1950 my company, the Consolidated Edison Co. of New York, was having a particularly difficult time and was being rather seriously attacked by the city and the press for not making more rapid progress in its air pollution control program, even though it had already spent some millions of dollars. I was told that if I wanted to see evidence of fine cooperation, I should visit Cleveland.

I made two trips, one on the occasion of a luncheon of the Cleveland Citizens Committee, to hear the second report on progress since the formation of the committee. At this time, the air pollution control officer was H. G. Dyktor, Commissioner, Division of Air Pollution Control for the city of Cleveland. I was tremendously impressed, for here were representatives of all the industries, the lake carriers, the municipal officials, and the press and civic associations. They were obviously working in the closest harmony and all had programs for improvement upon which they were working.

I came back to New York full of enthusiasm and hoped that we might gather together a similar representative group. I soon found out that New York was quite different inasmuch as Con Edison supplies the electricity for practically all the plants in the city as well as steam for heating most of the famous skyscrapers, and there are very few industries which have boiler plants of their own. The general impression was that since Con Edison was burning nearly half of the fuel consumed in New York, its stacks were in effect the stacks of the city and others saw no reason for getting into the act.

This put even more of a responsibility on us to be sure that we did a good job. We must be ready to talk to all groups who show any interest. We must invite them in to see for themselves just what is being done. Above all, we must be sure that we in all cases are entirely truthful, admitting any deficiencies, and show good faith in earnestly pushing our control program, which has cost Con Edison for work completed and approved since 1937 well over $100 million. We find that there are many interested groups in New York, including the New York City Federation of Women's Clubs, the Commerce and Industry Association, chambers of commerce, various local civic organizations, etc. We are glad to participate in the programs put on by the universities and the schools, and it is interesting to find that New York public school classes, even down to the fourth grade, have shown interest in air pollution.

We have participated in various research programs and continually watch all new developments which may be of help. Incidentally, I notice that Mr. Bodine has made reference in his paper to the fact that private resources for research are important, but that in some cases the knowledge gained has not been made public. He suggests that any companies having such information should be compelled to place it in the public domain. I know of no such instance and I am sure from our own viewpoint we consider it absolutely essential to pass on any information we may gain through research experiment or actual operating experience.

Mr. Bodine's organization and proposed methods of operation fascinate me, and I shall watch further developments with great interest. At the present time, from my own experience, I am somewhat doubtful that a similar organization could be assembled in the New York metropolitan area. We do have, however, a somewhat different type of cooperating organization, originally known as the Mayor's Conference but now known as the Metropolitan Regional Council. This organization was set up a few years ago at the instigation of New York City's Mayor Wagner and it is made up of the various mayors and other public officials in 16 metropolitan counties of New York, New Jersey, and Connecticut. Another group known as the Cooperative Committee on Air Pollution was organized in 1959 and is composed of the top officials of the New York State Air Pollution Control Board, the New Jersey State Air Pollution Control Board, the New Jersey Department of Health, and the New York City Department of Air Pollution Control. To this group more recently has been added the Interstate Sanitation Commission. This latter group and a special committee of the aforementioned Metropolitan Regional Council have made an important start in getting together for

tackling the air pollution control problem on a cooperative basis. They do not, however, have representatives from business, from industry, or from the public, but the officials involved are in close contact with the latter groups through other organizations.

Incidentally, I should also like to mention the Air Pollution Control League of Greater Cincinnati. This was organized way back in 1906 and it is a citizens' nonprofit organization which has been carrying on an intensive program of public education for many years in the Metropolitan Cincinnati area. This is another community activity organization which has greatly impressed me with its effectiveness.

I know there are many other organizations throughout the country devoting time to this important subject with varying degrees of effectiveness. I consider it essential that such organizations be encouraged to continue their activities and that the formation of other groups be promoted. The common aim should always be cooperation, education, and the presentation of a united front against the common enemy—air pollution. We might say that we are all hoping to be smoking less and enjoying it more.

DISCUSSION

Yolande Lyon. I am the health education consultant in the air pollution program of the California Department of Public Health. I would like to reinforce a statement made by Dr. Rossi in his talk. He said that public opinion formation is a group process and cannot be brought about by the use of the mass media alone. I think this needs to be reiterated in this group because, when I look at the programs of education conducted by the various agencies working in the field of air pollution control, it becomes almost immediately evident that the main reliance is placed on the use of the newspaper columns, radio, television, and so on. Now, I don't want to take away from the importance of these media for 1 minute, but I think we need to devote a little more thought to how we are using these media. We need perhaps to devote a little more thought to what the processes are by which change takes place in a community, the processes which make people willing to act. Perhaps it is time we paid some attention to the thinking of the social psychologists, at least more than we have done, rather than having an almost primitive faith in just straight publicity, used in a sort of shotgun fashion.

Rossi. I should like to know, Miss Lyon, if what you were indicating was that the mass media are not supposed to influence people directly so much as indirectly, through the groups in which they live and work, through their peers, and so forth. If that is the case, I certainly must agree. Do you want to clarify this a little further?

Lyon. Yes. I think there is a process by which people who are skilled in public relations make sure that their efforts are geared with those of other organizations in the community which are able and willing to identify themselves with a cause and work for it.

Dixon. The mass media always defend themselves when they are accused of doing something bad by saying in effect: "Well, we haven't influenced anyone directly; these children are influenced by their parents and by their peers." However, if we inquire further as to who is influencing the parents and who is influencing the peers, we find out that they are influenced by the media also. Now this is a different approach because it implies that the media alone cannot do anything that is useful. Here again, of course, they can start something, but each of your various groups must be approached separately in the light of its own primary interests. I think this is probably true. I do not think it is necessary to overestimate what the mass media can do in order to say that you still have to use them as effectively as possible. Dr. Rossi, do you wish to comment further?

Rossi. Yes. One of the things that my organization has done over the past 10 years is to evaluate public information campaign after public information campaign, and one of the horrifying results that keeps coming up is that a public information campaign which uses exclusively mass media and does not attempt to tie in to the existing organizational apparatus of the community is generally a miserable failure. Indeed, more than that, it sometimes has a boomerang effect. Take, for example, campaigns to get people to come to the venereal disease clinics which rely exclusively on spot commercials. This procedure was actually employed in Columbus, Ohio, in 1948. It drove the number of entrants into the VD clinic down to practically zero.

Or take a campaign in Cincinnati around the same time, to increase support for the United Nations. This was supported by spot commercials, newspaper ads, special radio programs, and even the New York Times magazine section which is, of course, always widely read in that area. This increased the amount of information about the United Nations and its most essential aspects as an international organization by about 1 percent of the general population.

If you come into a place and saturate it with this type of information, through this type of media coverage, without at the same time interesting an organization such as Penjerdel, which is the proper audience for this kind of campaign, you are just wasting your resources and your time. This is not to deny what Mr. Seldes has said, that the mass media have tremendous effects. The effects, however, are small accretions over a long time. Sure, we are all using well-advertised toothpaste, razor blades, and breakfast cereals—and I think these are the massive effects of the mass media—but these are effects which result from virtually years and years of minute effects accumulated one upon the other.

Thomas F. Williams. I do not disagree with Miss Lyon or Dr. Rossi in their assertions that the use of mass media alone is not enough. In defense of mass media and publicity in general, however, I feel that we ought to emphasize that the primary purpose of the use of mass media in air pollution—

and I hope this does not sound too credulous and naive even in our time of public relations sophistication and confusion—is to convey to all sorts of people the essence of what is known by experts in the field. Until we have really done this it may be premature to worry about whether or not people will need to be otherwise motivated to solve air pollution problems.

I think that some of the parallels that have been drawn between our public information efforts and Madison Avenue methods of selling merchandise are extremely farfetched. We know that every one of 10 brands of toothpaste will do the same identical job, and if one happens to have a catchier slogan than the others, that one becomes "the people's choice." There is not much parallel between that sort of thing and our assignment of informing the public about the basic facts of air pollution. After the people have been informed, even our commercially oriented society is likely to find a way to keep them pleased. That is to say, once they are aware that a problem exists, that it adversely affects their own interests, and that there are means at hand to take care of it, they will know how—we hope—to get something done about it.

Unidentified. At the time of, or shortly after, the Berlin crisis 2 years ago, the Chicago Sun-Times distributed the Office of Civil Defense booklet. The grand result of this great dissemination of information, which reached a large proportion of all households in the Chicago metropolitan area, was exactly six fallout shelters. This is the kind of great flop that you have to watch out for. The information in the booklet was not clear and there were also disagreements in other media about what should be done by an individual. Furthermore, the precise method whereby one would go about building a fallout shelter, or under what conditions one should do so, were not clearly laid out. So there's an example of a public information campaign which certainly did not increase public awareness of what to do about fallout shelters. Sometimes you make tremendous joking opportunities for comics on the radio and television without getting the public action you were looking for.

Williams. I think we often strain too much to be sophisticated about why people respond or do not respond to publicity. People do not get excited about building fallout shelters, for the simple reason that they are not convinced that fallout shelters make a great deal of difference, one way or the other. I don't think this is true in the field of air pollution. I believe that once the people have really had an opportunity to understand the reasons for, and the advantages of, air pollution control, air pollution will be controlled. I think it is naive or cynical, or both, to think that public information efforts to date have been so massive and so successful that the public has already been given a fair chance to really understand the air pollution problem.

In the selling of any product, even commercial advertisers know that it must do something for the buyer. It must serve some purpose which to the buyer is useful, even though this might be nothing more than a vague feeling of prestige that can be associated more readily with the advertisement than with the product. In the field of air pollution, we are not in such a desperate position. What's more, we are not only asking the public to do something; we are also asking the public to help us determine what ought to be done. In my opinion, we have a long way to go before we reach the saturation point—if there is one—where it is no longer useful to inform people about the essential facts—technical, social, and political—of this very complicated problem.

Lyon. Perhaps Mr. Atkisson will comment on this because he has worked with community groups in Los Angeles and might shed some light on it.

Dixon. Do you want to comment on this, apart from your concluding remarks, Mr. Atkisson?

Atkisson. In Los Angeles we have faced a somewhat different problem. Our air pollution problem was so large that we already had in existence an aroused public, and our main task was to direct this vast reservoir of energy into the proper channels. The public was alert, it was sensitive to air pollution, it was an eager readership, and I think we did use the mass media effectively. And it was very apparent that the public did read and listen to what was presented to them in the mass media and that they did respond to these messages.

In fiscal year 1953–54, for example, the agency overspent its budget by a sum of $1½ million and this presented no problem of any magnitude to anyone; the following year that sum was provided, plus an additional million. Air pollution has been very well supported financially in Los Angeles County because of this reservior of public support. When we finally asked the public to support a complete and absolute ban on all forms of refuse burning in the county, they responded again. We had expected a good deal of noncompliance, and had hired some

40 additional uniformed inspectors in order to conduct a field enforcement program, but we did not need these officers and, a year later, they were released from the payroll. The public had responded effectively. Granted, Miss Lyon, we did work very closely with civic groups. We also used a multifaceted public information program; we didn't put all our eggs in one basket. Our activity was successful. Why it was successful I'm not really sure, but I suspect that the tremendous built-in interest of the public had a good deal to do with it.

Dixon. No one else wants the last word. So the last word goes by fiat to Mr. Atkisson, who is our diligent recorder for this session.

CONCLUDING REMARKS

ARTHUR A. ATKISSON
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Air Pollution Control District
County of Los Angeles, Calif.

I suggest that we now conduct three separate tests: Test No. 1, my ability to read my own handwriting; Test No. 2, the ability of our experts on communication to transmit; and Test No. 3, the ability of your reporter to receive. With these three important qualifications in mind, I'd like to proceed to capture, if I can, the thread of thought that's been presented here.

Actually, I think this thread of thought began at the previous panel session which ended this morning. The reporter for that session, Irving Michelson, who I think is in the room somewhere, wrapped up his session by quoting Dr. Arie Haagen-Smit somewhat as follows: "Air pollution control is always a balance between the desire of obtaining as clear air as possible and the price the community is willing to pay for reaching this goal." In commenting on this, Mr. Michelson said: "A community will be willing to pay the necessary costs only when it is convinced that either the comfort and health of its inhabitants will be increased or their economic burdens will be eased." A keyword here is "convinced" and this implies an educational process.

Dean Seldes began our program by commenting that communication after all is what precedes decision and action, but that to communicate we must both transmit and receive. There are two functions involved in the process. To be sure that what we transmit is really received, heard, and used, to insure that it really affects the attitudes and behavior of people, we must create a receptive climate for our communications. In Seldes' words, "We must effect a change of atmosphere." The need for cleaner air is now recognized, he added, but the real possibilities for controlling community air pollution problems are not understood. Incidentally, in another session this afternoon, a paper was delivered by an engineer who offered much the same view and asked how long communities should wait to control air pollution when adequate technologic means are now available for controlling most significant air pollution sources. Dean Seldes then underscored the need for "shouting from the housetops." What we need, he said, is a lot of emphasis on the possibilities of, and the need for, control, and we have to deliver these messages in multiple ways to multiple audiences.

I think that Dr. Rossi agreed with this point of view and argued that the way to get action on air pollution is to put air pollution not out of, but into, politics. He pointed out that the decision-makers in American communities must be reached and that those decision-makers are after all politicians. The way they behave involves a political process and the way we reach them involves a political process. What we need is a good deal more politics, not less, in air pollution, using politics in the best sense of that word.

John Bebout argued, however, that the structure of decision-making in our communities—the web of authority and the sphere of control decision-makers have—does present some very real problems in air pollution control. He pointed out that in many States both constitutional revisions and statutory changes are needed in order to give the State and its creatures—counties, municipalities, and other local governments—new powers to match the new needs of governments in the metropolitan age. I have the feeling that he was reading back to us some of the arguments of the late Senator Richard Neuberger, who argued that there was a hand of the past

that was reaching out to straitjacket governments, and particularly local governments, throughout the Nation. The configuration of our local governmental structures must be altered, he argued, and so also must our allocation of decision-making responsibilities to those bodies. Advocates of clean air therefore must not only argue the cause of clean air but must also make common cause with persons interested in modernizing our governmental machinery for the purpose of facilitating the performance of other vital public services.

Once the importance of the decision-makers was established, all panel members recognized that we must "communicate" and somehow influence these decision-makers in the cause of clean air. So we must return again to Dr. Rossi and his argument that air pollution must be put into politics and that we must actively attempt to influence community decisions. As to how we are to do this, he defines two targets, the general public and the political or decision-making elite in a community. In a somewhat less academic way, I think he was also saying that we have to identify at the outset whose ox is being gored in the air pollution control process. Where does the air pollution control process really affect most dramatically the interests of human beings and of human groups in our communities? Unless we can predict this and understand it, we have little hope of conducting effective informational programs, particularly those designed to influence values. He argued that effective communication therefore involves more than a mass appeal to a mass audience through the use of the mass media alone. This thesis Miss Lyon very effectively supported, I thought. In Dr. Rossi's words, "Before a proposed change in a community can become a proposition around which public opinion pro or con is formed, it must first come to the attention of the population; and second, be given an interpretation which engages the ongoing values and attitudes of the population." He concluded by emphasizing that the process of public opinion formation is a group process, and that the individual, as a single isolated entity, is rarely influenced by the mass media. Dr. Bebout warned again that it's time we got on with this job of informing and influencing the many publics we need to reach. He said we are in danger of postponing effective action to the point where it will take truly heroic efforts—and perhaps exact an appalling toll—to correct or overcome the effects of long neglect. State and national governments should get on with this job of acquiring information and engaging in education. Information, he asserted, is an important prerequisite to any effective political action for air pollution control at any level. Today it's at the State and Federal levels that we find an optimum capacity to acquire and transmit this information.

Congressman Cameron expressed his agreement with this view, based on his own experience as a legislator. He indicated that the electorate—and I assume, also the legislature—becomes indifferent as a result of conflicting claims on any proposition. In his view, there has been a lot of noise on some of our communication circuits in the air pollution business. We have to firm up and define somewhat more positively the base of information upon which all future action is dependent.

John Bodine explained how this kind of information collection and transmission job is being done so effectively in the Philadelphia area by the Penjerdel Corporation. George Minasian in turn reflected a similar point of view and cited his own experience in New York where, as a base for progress, it was necessary to form some groups not unlike those we heard about from other organizations represented here today, including a local section of the Air Pollution Control Association.

After having said all this, at what point do we really end up? What conclusions can we reach? I suggest that, first of all, we have to recognize that public action on any program must follow public perception of the need for action. In many communities the need for any kind of action is not yet recognized. And that in these communities there may not be the public consensus that is necessary. So this becomes the first important step we have to take: we must develop an awareness of the need for an air pollution control program of whatever sort.

Some months ago, Mr. Smith Griswold, the control officer in Los Angeles, delivered a speech in which he remarked that the great distinction between a medieval settlement and a modern community is perhaps to be found in the vast differences in their value systems; and that the values a community holds, therefore, influence dramatically the character of that community and the public programs that are possible there. So, where there is a lack of appreciation of the need for air pollution control, our first requirement must be to recognize the need for surmounting the prevailing barriers of apathy.

We must also show that, in communities which need control, effective control action is possible. I think we have to shout this rather clearly from the housetops, to as many audiences and in as many ways as we can. At some points in this national conference, I have gotten the feeling that there is some confusion about this, and that an impression prevails that technologically we are not yet able to control many significant sources of air pollution. I suggest that the evidence points quite clearly in the opposite direction.

How are we to act in response to these two conclusions? What can we do to cultivate public awareness of the need and the possibilities for control? The answers, I feel, remain somewhat obscure even after all our discussions. Although we all rather clearly recognize the techniques which must be applied to the job, little was offered to indicate just who is going to apply these techniques. I got the feeling that we were still talking about "those guys out there somewhere," who ought to start doing something to communicate more information to the public about air pollution. I think that this is one of the very real uncertainties in everyone's mind. Who is to do this information transmittal, this value-influencing job upon which all future progress in community air pollution control is dependent?

In any event, in my opinion, aggressive and intelligent public information and education efforts must be viewed, not as the icing on the agency cake, not as an unnecessary frill, but as a condition of progress in the air pollution control field. Its absence throughout the country, in control agency after control agency, may be the largest barrier to progress in our efforts to clean up the Nation's limited and overpolluted air supply. We should be giving attention, therefore, to the adequate financing of governmental public information activities, just as we do to air monitoring, permit processing, engineering, and source testing activities. It may be the most effective control tool available to us today. As John Bodine might put it, it's high time we got on with the job of building an effective public consensus on the needs and possibilities for air pollution abatement action.

BANQUET ADDRESS

ARTHUR S. FLEMMING
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Eugene, Oreg.

I regard it as an honor to receive an invitation to participate in the second National Conference on Air Pollution. I remember very distinctly the first conference that took place four years ago, soon after I took office as Secretary of Health, Education, and Welfare.

As a citizen of this country, I am delighted that there is a Department of our government that is deeply concerned about "dirty water" and "dirty air." As a former member of the Department, I can testify to the fact that, contrary to some recently published statements, "dirty looks" is not one of its characteristics. Dedication to programs that are directly related to the welfare of our fellow human beings doesn't lead to "dirty looks"—it leads to a feeling of satisfaction that comes only to those who devote their lives to service. I can assure you that I am more than happy to have the opportunity of coming back to Washington in order to participate in what is certainly one of the Department of Health, Education, and Welfare's most significant programs.

I am sure that by now, in the course of this Conference, you have heard considerable testimony relative to the existence of air pollution, to its impact on the health and welfare of the Nation, and to the steps that have been taken and must be taken in order to clear the air.

I will add to that testimony by saying that for the last few days we have been experiencing in Portland and the Willamette Valley of Oregon—one of the most beautiful valleys in the world—a very serious build-up of air contamination. A staff writer for the *Portland Oregonian* yesterday wound up a series of articles on air pollution in Portland and the Willamette Valley by concluding that the problem is getting worse, not better.

My own familiarity with the type of evidence you have been considering over the past few days leads me to concur wholeheartedly in the observation made by the former Deputy Surgeon General, Dr. John Porterfield, when he said: "With all this probing of outer space and piercing of inner space we tend to neglect the mundane, prosaic middle ground in which we live and breathe. As a matter of cold hard fact, we are closer to putting a man on the moon than we are to creating a thoroughly healthy, pleasant environment on this earth for man to live in—closer in know-how, closer in time, closer in probability of achievement."

The indictment by Dr. Porterfield is thoroughly justified by the facts. And I am sure that significant progress in dealing with air pollution will take place only if the Federal Government plays a far more effective role than it does today. I recognize the very important roles which business, industry, and the State and local governments are playing in air pollution. I believe, however, that their activities alone will not reduce in a significant manner the serious health hazards that you and I face today. They will be reduced only if both the resources and the authority of the Federal Government are used to a much greater degree than they are being used today.

It is in the light of these convictions that I would like to discuss with you this evening some of my own beliefs, and my reasons for them, relative to what the Federal Government should be doing in order to make a significant contribution in the direction of clearing the air.

First of all, on the basis of my experiences in the Federal Government, I believe that its activities in the area of air pollution should be centralized in an environmental health unit in the Public Health Service. I admire the intelligent and dedicated approach that the Public Health Service has taken to the Nation's environmental health problems. Despite its very limited resources, the Public Health Service can point to significant accomplishments. As a nation we are indebted to the Public

Health Service for the quality of leadership it has demonstrated in this area.

There are those who become very much interested in a particular environmental health program, such as water pollution, to name one. In all sincerity, they decide that the only way to get adequate resources for the activity in which they are involved is to put it in the Office of the Secretary instead of leaving it in the Public Health Service. I have come to think of such persons as status-seekers for the activities in which they have a particular interest.

I disagree with these persons. I believe that the Secretary's office should not be charged with the operation of *any* specific program. It is the responsibility of the Office of the Secretary to see to it that *all* programs for which the Department is responsible are operated in an effective manner. Once you lift any aspect of the environmental health program out of the Public Health Service, you deprive it of resources that are needed for an effective program.

I agree wholeheartedly with the recommendation of the committee on environmental health problems that made a report to the Surgeon General and to the Secretary a little over a year ago. The committee recommended the creation of a unit within the Public Health Service where responsibility for all environmental health problems would be centered. I am convinced that if this recommendation were carried out it would strenghten water pollution control programs; I am convinced that it would strengthen the occupational and radiological health programs; and I am likewise convinced that it would strengthen the air pollution program. Centralization of environmental health programs in this manner would make it possible for the Public Health Service to pool effectively its total resources, and all of the specific programs that would be a part of this operation would gain from it. I am sure that those who are interested in the Federal Government's role in the environmental health field, specifically in the area of air pollution, will support this recommendation on the part of a very distinguished committee of advisors.

In the second place, I believe that the Federal Government should be given additional resources for research and training programs in the area of air pollution. As all of us know, the Public Health Service air pollution program has been operating under an authorized budget ceiling of five million dollars a year. This just doesn't make sense. The law should be amended so that there is no appropriation ceiling, so that the appropriations committees of both the House and the Senate can determine each year what is a satisfactory and adequate amount to appropriate for this program.

All of us recognize, and I am sure that this has been brought out in your discussions here in the last few days, that we have many hundreds of problems that will be solved only if we are willing to make a greater investment in research than we are now making from both public and private resources.

In addition, all of us are aware of our present and protracted shortages of qualified manpower in this area. I believe that the Federal Government should be in a position to make a much heavier investment for training programs—both of a short-term and a long-term nature—to help alleviate the present shortage and to put us in a much stronger position to meet future demands for trained personnel.

In the third place, I think the Federal Government should be able to make project grants, normally on a matching basis, of limited duration, to air pollution control agencies for the development, initiation, or improvement of State and local control programs. There is no Department of the Federal Government that has had more experience with this type of nationwide program than has the Department of Health, Education, and Welfare. No one who has had the opportunity of observing these programs in action could deny that they have resulted in accelerated activity in the areas where they have been used. Certainly this type of program has demonstrated its ability to accelerate the Nation's determination to deal with a problem such as water pollution in an adequate and satisfactory manner.

Our generation is entitled to accelerated activity in the interest of removing the serious health hazard posed by air pollution. In my mind, there can be no question that a program of project grants would result in substantially increased activity at both State and local levels. I can see no reason at all why, as a nation, we should not decide to make this investment.

In the fourth place, the Federal Government should be given enforcement authority in air pollution comparable to the authority it now has in water pollution.

It so happens that I had the opportunity as Secretary of initiating some of the early enforcement ac-

tions in the water pollution area. I believe that the enforcement authority in the Water Pollution Control Act has been used in a fair and constructive manner and, as a result, certain things have been achieved that never would have been possible if the Federal Government had not been given authority to act.

I believe that the Federal Government should have just as much authority to act in the air pollution area. Briefly, without going into too much detail, this is what I am talking about. The Surgeon General, on his own authority in cases of interstate problems, or by invitation from State or local officials in cases of problems within their own boundaries that result from air pollution originating in other jurisdictions, should have the authority to call a conference to take a look at a specific air pollution situation. Following the conference, the Surgeon General should have the authority to forward appropriate recommendations to all who are in a position to act in order to clean up the polluted air. If after six months, for example, action is not taken, the Secretary of Health, Education, and Welfare should have the right to create a board to conduct fact-finding hearings and to make recommendations to him based on the findings of fact. The law should specify that this board be set up in such a manner as to assure a fair and objective evaluation of the evidence.

Then the Secretary, it seems to me, should have the right to issue orders based on the recommendations of the board and which would become operative after a reasonable period of time had elapsed. The recipients of the orders should have the right to appeal to the appropriate U.S. Circuit Court of Appeals within a specified period of time. If the orders are not appealed or if they are appealed and affirmed but are not complied with, the Secretary of Health, Education, and Welfare should be able to refer the matter for appropriate action to the Department of Justice.

In substance, this is the procedure provided for in the Water Pollution Control Act. I recognize that the present Administration, in making recommendations for legislation to the Congress at the last session, did not go this far. However, its recommendations were comparable to those made by the previous Administration. As a result of my experience with and direct knowledge of air pollution problems, and in the light of the experiences the Department has had in the water pollution field, I am convinced there is no reason at all why the Federal Government should not have equal authority in both of these environmental health fields. I have noted with interest that Senator Maureen Neuberger of my own State of Oregon introduced during the last session of Congress a bill which would have given the Federal Government the same authority in air pollution it now has in water pollution. She feels, and I concur, that unless the Federal Government is given this authority and exercises it, we are not going to make the kind of progress in the elimination of this health hazard that should be made.

Now I know there are many who would say that this authority is not needed, and they would point to the substantial progress that has been made without such authority. I respect those who are responsible for this progress. But I submit to you that there is still too much evidence pointing to the fact that there are those who put selfish economic interests ahead of the health of our Nation and resent and resist the efforts of others who put the health of the Nation ahead of all other considerations.

And so, as I think of this air pollution problem, my plea to you is, let's approach it with a sense of urgency. Let's make up our minds that we are going to use all of our resources in order to do something significant in this generation. Let's not wait until tragedy again strikes. Let's get action at the next session of Congress.

It took a tragic development to get the kind of action in the food and drug area that we have been seeking for quite a number of years. Let's not wait for another dramatic, tragic situation to develop in air pollution before we demand action. Let's insist that the Congress provide adequate legislation in the air pollution area just as it has provided adequate legislation in the water pollution area. Air pollution problems—just as urgent, just as important—demand it. I am confident that as a result of this conference there is a better possibility for action at the next session of Congress than would otherwise be the case. I am confident, too, that you are approaching this problem with a sense of urgency and with a determination to solve it, now. Congratulations on your willingness to give time, thought, energy, and resources to tackle the problem of polluted air. As a nation, we are indebted to you, and I know that you are going to help our nation get constructive results.

Thank you.

THIRD PLENARY SESSION

[redacted]

LET'S CLEAR THE AIR!

Reports of Panel Chairmen

PARTICIPANTS

Chairman: VERNON G. MACKENZIE, Chief, Division of Air Pollution, Public Health Service

Panel A: Wolfgang E. Meyer

Panel B: Lewis W. Cadwallader

Panel C: William S. Spicer, Jr.

Panel D: John T. Middleton

Panel E: Glenn R. Hilst

Panel F: Melvin W. First

Panel G: Erwin E. Schulze

Panel H: James Dixon

Report of the Chairman, Panel A
THE AUTOMOBILE, THE TRUCK, AND THE BUS

WOLFGANG E. MEYER

The panel covered a wide range of subjects on air pollution by motor vehicles. The pollutants that are emitted, the role and effects of these pollutants, control methods, public policy, control programs, and the impact on the motoring public were dealt with.

In his introductory remarks the chairman pointed out that it is not only the exhaust system of an engine that discharges contaminants to the atmosphere, but that, at least in the case of gasoline engines, the engine crankcase is another important source. Also, fuel vapors escape through vents from the fuel tank and the carburetor.

Although many compounds are present in the exhaust gases of gasoline engines, those of greatest importance to air pollution are hydrocarbons, carbon monoxide, and oxides of nitrogen. The major pollutants discharged from the crankcase, fuel tank, and carburetor are hydrocarbons. Measurements have shown that, among the emission sources of gasoline engines, exhaust and crankcase are the most significant ones. The sources of evaporative losses are far less important by comparison.

The diesel engine differs from the gasoline engine in that it uses less volatile fuels, that it operates at higher air-fuel ratios, and that it employs different fuel supply and ignition means. These as well as other factors account for important differences in the combustion process and consequently in exhaust emissions. Diesel exhaust is lower in hydrocarbons and carbon monoxide than that of gasoline engines, but slightly higher in oxides of nitrogen.

In contrast to gasoline engine blowby gases, those of diesels contain only small quantities of pollutants because the diesel compresses air only, instead of a fuel-air mixture. Since diesel fuel is less volatile and the fuel system is closed, evaporative losses are effectively nil.

Diesel engines, however, present a more serious problem with regard to smoke and odor as compared to gasoline engines. Properly maintained and adjusted diesel engines emit, at their worst, only very faint smoke. The black diesel exhaust smoke that justly causes complaints and concern can be controlled by scrupulous maintenance and retention of the factory adjustment of the fuel system.

The causes of the diesel odor have not yet been identified conclusively and therefore control methods are still lacking. It is well to remember, however, that poorly tuned gasoline engines can also generate a great deal of odor.

The total emission of objectionable substances from a single vehicle is neither large nor, under most circumstances, serious. It is the operation of great numbers of vehicles in one area that can create an air pollution problem, but the uncertainty concerning the effects of the emissions and their low concentrations make control problematical and difficult.

Dr. Leslie Chambers, director, Allan Hancock Foundation, University of Southern California, in speaking about "Relation of Vehicle Air Pollution to Pollution From Other Sources," made it clear that we cannot consider air pollution from motor vehicles and from other sources as separate problems. Also, "total air pollution load" has little meaning without a knowledge of what constitutes this total load. He pointed out that there is need for much further research on what happens to pollutants in the atmosphere and that, at the present state of knowledge, it is difficult to predict the effects that air pollution controls will have on air quality.

It is unwise to concentrate on the elimination of any single source of pollution; all sources contribute

to the objectionable qualities of a polluted atmosphere. In spite of current—and justifiable—concentration on abatement of vehicular pollutants, it is obvious that some kinds of pollution already recognized as objectionable and hazardous have little or no relationship to the automobile.

Dr. Chambers cautioned that the battle of air pollution cannot be finally won as long as the number of sources is steadily increasing, just as the last schoolroom cannot be built as long as the number of students increases.

Dr. Norton Nelson, professor and director, Institute of Industrial Medicine, New York University Medical Center, who spoke on "Effects of Motor Vehicle Pollutants," indicated that it was still not possible to make accurate appraisals of the economic losses attributable to air pollution, but that this burden was a great one to the individual, to the community, and to the Nation. The development of procedures for precisely assessing economic losses clearly deserves increased effort.

Most of Dr. Nelson's attention was directed toward the adverse effects of air pollution on vegetation and health. The damages caused by air pollution to crops, forests, and ornamental plants have been known for a long time. In fact, often these effects are the first indicators of serious air pollution in an area. Annual smog damage to which motor vehicles prominently contribute has been estimated in California to be $8 million. Similarly, air pollution damage to agricultural crops in the eastern part of the United States has been estimated at $18 million per year. It is believed that this damage is mostly from ozone for the abundance of which again auto emissions are being blamed.

Turning to the effects of air pollution on man, odor and eye irritation are the most commonly experienced effects. Although these do not lead to actual disease, they are nevertheless sources of widespread complaint.

The extent of health impairment resulting from the typical levels of air pollution found in major cities is of serious concern to the public and to researchers. This presents a difficult problem and precise answers will require research methods of a higher degree of refinement than are available today. The difficulty in defining the health effects of air pollution results from the fact that there is no specific air pollution disease. On the contrary, there is good reason to believe that air pollution acts primarily through the exacerbation of existing diseases.

Dr. Nelson believes that a number of very strong leads do suggest association between air contaminants and disease. Extensive and painstaking research now underway is expected to provide scientific support for what are now largely suspicions. Although one cannot always clearly distinguish the role of auto emissions in the disease mechanisms, Dr. Nelson considers this source as generally significant and often predominant.

Mr. J. M. Chandler, speaking for the Automobile Manufacturers Association, reported on the contribution of the automobile industry to the control of motor vehicle emissions. Before control devices could be developed, it was necessary to obtain data on the emissions. The Automobile Manufacturers Association played a vital role in such studies. He detailed the efforts of the automobile and related industries in seeking solutions to the motor vehicle emission problem. At present, development of catalytic and flame-type afterburners continues, and several such devices are undergoing test and evaluation in California.

The crankcase emission problem has been successfully resolved. Beginning with the 1961 model year, all American automobiles sold in California were equipped voluntarily with systems to effectively eliminate the crankcase as a source of hydrocarbons. In this instance the solution was simple and involved adapting systems that had been used for many years in special applications. Favorable experience in California led to the automobile industry's decision to install blowby devices on a nationwide basis when the U.S. Public Health Service stated this was desirable. Thus all 1963 American-made gasoline-powered vehicles are equipped voluntarily on a nationwide basis with positive crankcase ventilation systems. This is considered a significant step in the fight against air pollution by motor vehicles, since about 40 percent of the hydrocarbons emitted by engines find their way into the atmosphere through the crankcase.

In the opinion of Mr. Chandler, a new dimension has now been added to the design of automobiles. To the usual criteria of engine design—performance, cost, and fuel economy—has been added a fourth criterion—emissions.

Even after a new engine type with lower emissions has been successfully developed, it will be some time before such engines will be available to the public because of the time required for production engineering and tooling. Therefore the importance of obtaining reduction in emissions by

modification of engines currently in production remains high.

The automobile industry urges all communities in which motor vehicle emissions are proven to be an important factor in air pollution to consider the significant benefits that can be derived from vehicle maintenance and inspection programs that supplement the positive crankcase emission systems.

The Honorable Paul F. Schenck, Congressman from Ohio, discussed "Public Policy in Motor Vehicle Pollution Control." He posed a number of questions:

Should pollution from motor vehicles be controlled? If so, to what extent and by whom? Is a national policy necessary or can satisfactory solutions be achieved by each of the 50 States?

In considering the need for public policy, we must recognize that it is vital to maintain the quality of our air resources. These resources are not limitless and a growing population and expanding technology are placing ever-increasing demands on them.

The motor vehicle presents a problem that differs from that posed by other air pollution sources because it represents a large number of small, mobile sources.

Congressman Schenck asked: Who has the responsibility for dealing with air pollution from motor vehicles? The industry that produces the vehicles? The public that uses them? The government? He felt all three must share the burden.

The automobile industry has the responsibility to develop motor vehicles with reduced emissions. The individual car owner has the responsibility to maintain this vehicle in a state of repair that assures the lowest possible emission level. Government must take whatever steps are necessary to keep off the road vehicles that discharge large quantities of pollutants.

Congressman Schenck felt that, at the national level, Government should exert vigorous leadership. It should stimulate the development of cars that do not pollute the air; it should support the necessary research; it should develop criteria to serve as benchmarks for those who design and produce engines; and it should assist in furthering our knowledge of what air pollution does to human health, to vegetation, and to property.

Mr. J. A. Maga, chief, Bureau of Sanitation, California State Department of Public Health, in his discussion, "The Rationale of Motor Vehicle Emission Control," outlined the factors that must be considered in any control program. Among these factors are the concentration and volume of pollutants discharged by motor vehicles, the total pollutants from vehicular and nonvehicular sources, the atmospheric concentration of contaminants, the adverse effects experienced, and the desired goal of air quality. The steps taken in California were cited as an example of one approach to this problem.

In California numerous studies demonstrated conclusively the need for control of motor vehicle emissions. The question was no longer, should this be done, but rather, how should it be done, and what legal and administrative steps were required. It was decided that the first step should be the establishment of air quality standards for communities. These standards, together with information on such factors as emission and atmospheric concentration of pollutants, would then be used to calculate motor vehicle emission standards.

The State legislature required the department of public health to set standards on air quality and on emissions from vehicles. In the following year the legislature established a State program for the control of these emissions by requiring the installation of devices that comply with the emission standards. An independent Motor Vehicle Pollution Control Board was created to carry out the control program. The law contains a number of safeguards of the public interest, as well as schedules for installation of devices after two or more have been found to meet the standards and the criteria of the board. While California's program may not be one that every State should follow, most of the factors that were considered there will also have to be taken into account elsewhere.

Mr. Tom Bright, director, California Department of Motor Vehicles and a member of the California Motor Vehicle Pollution Control Board, described the efforts of that board and the problems inherent in a motor vehicle pollution control program. He reported that a great deal of progress has been made. The board has approved a number of crankcase control devices and is currently testing several exhaust control devices. The board proceeded with care and discretion in setting criteria to be followed by device manufacturers on longevity, effect on engine operation, safety, and ability of the device to operate under a wide range of driving conditions. Each of these presented problems that had to be considered in detail and resolved.

One of the most important problems that still faces the board is that of enforcement and compliance. The present law is concerned with the initial installation of control devices. It does not include anything about inspection and enforcement. A committee of the board is now engaged in developing a workable program to assure satisfactory long-term operation of approved devices.

One of the considerations in enforcement is that once two or more devices are certified, they must be installed according to a prescribed schedule over a period of 3 years on all vehicles for which the law prescribes control devices.

Mr. Bright emphasized that many factors must be taken into account by the motor vehicle administrator in addition to the registration requirements of a vehicle. The problem of enforcement and inspection is fairly simple for new vehicles, but complex for used ones.

It is expected that most of the questions on how to accomplish inspection will be answered in the next few months. Some of the possibilities receiving consideration include the use of licensed inspection stations, of windshield stickers and distinctive code entries on the vehicle registration card to indicate presence and condition of the devices.

Mr. Burton Marsh, director, Traffic Engineering and Safety Department, American Automobile Association, viewed motor vehicle emission control from the standpoint of the motoring public. He pointed out that the motoring public represents a very large proportion of the American public—with three out of four families owning at least one motor vehicle.

The American public generally responds sensibly to matters which are appropriate for public decision or individual action, provided the public is properly informed. In Mr. Marsh's judgment the motoring public is not convinced that the motor vehicle is a major factor in the air pollution of most urban areas.

If facts prove that vehicles are a substantial factor in the air pollution of an area, one of the greatest needs is to effectively inform the public. It will expect the technical experts to answer pertinent questions in a simple and clear way so that the average motorist can understand the problem and the needs. Sound judgment must be used in developing public opinion.

Mr. Marsh stressed that the motoring public has the right to expect that sound and orderly control procedures will be followed. If a community or State desires to obtain action, it should obtain the facts, develop reasonable and effective methods for correcting the situation, and have an effective program of public information.

The information should include all the facts to substantiate the need for pollution control devices. Such information should include realistic data on cost, installation, and maintenance of the devices. The public information program must pay special attention to what are considered to be appropriate financial and other responsibilities of the motorists as to air pollution control.

A number of individuals directed questions to the members of the panel during the discussion period. No one questioned the philosophy that had been expounded by the speakers or the factors that must be considered in programs for the control of motor vehicle emissions. Questions and comments dealt mainly with methods of control and problems arising from the use of control devices. The need to consider the role of rapid transit as one means of air pollution abatement was pointed out.

In his concluding remarks, the cochairman of the panel, J. D. Caplan, chairman, Vehicle Combustion Products Committee, Automobile Manufacturers Association, stated that the speakers had made several important points that required emphasis. First, impatience should not lead us to institute controls before it is clearly established that they will do good rather than harm. Secondly, we should not place our hopes on wishful solutions to motor vehicle emissions, but must temper our dedication with a sense of the practical. Thirdly, we must realize that maintenance, inspection, and enforcement may be more costly to the individual motorist than the control device per se. Finally, even with general agreement on the philosophy of establishing motor vehicle control requirements, such agreement will be for naught if the basic facts are not properly known and recognized.

The chairman expressed the opinion that the formal presentations as well as the discussions indicate the great deal of interest, research, and activity concerning air pollution by motor vehicles. One is always tempted to report that the problems in which one is involved are complex. The chairman believed himself justified in describing the problem of air pollution from motor vehicles as indeed being complex and one that has the broadest public impact. While many problems remain, much has already been learned, and much has already been accomplished.

Report of the Chairman, Panel B
THE INDUSTRIAL PLANT, THE POWERPLANT, AND THE MUNICIPALITY

LEWIS W. CADWALLADER

In discussing methods to be used in clearing the air, Panel B examined a number of factors which affect decisions with respect to how, if, when, and to what extent industrial and domestic atmospheric pollutants may be controlled. Health, economic, political, social, scientific, administrative, and regulatory considerations were discussed.

It was stated that most industrial and municipal pollution problems are susceptible to economic methods of control. The economic factors which affect the choice of a level of control were related to the total cost to the community. The cost of control (the money spent for industrial air cleaning devices, the control of dumps, etc.) was related to the total economic impact upon the community.

The air pollution and control problems faced by the more than 300,000 manufacturing establishments in the United States vary widely. The nature of emissions from a number of industrial operations was reviewed. It was emphasized that air pollution control not only involves the installation of control equipment but may also involve process and raw material modifications.

No 2 of those 300,000 manufacturing establishments are exactly alike in their emissions of air pollutants. Those with the greatest pollutant potential may be classified into five groups:

1. *The Dusty Industries*

The various dusts emitted differ one from another in chemical composition, in density, in particle size range, and in amounts emitted. Generally, the primary problems resulting from dust emissions are the dustfall nuisance from the larger particle sizes and the visibility restriction from the smaller ones.

2. *The Smoky Industries*

The combustion of fuels is the common denominator of all industry. Most of the problems caused by dust and smoke emissions have been solved technically and any continuing emission of dense smoke is unnecessary and inexcusable.

3. *Odors*

Probably the most annoying and difficult of all air pollution problems is the odor problem. The chief effect of industrial odors is the esthetic offense against the sense of smell.

4. *Irritating and Toxic Substances*

The most common irritating or potentially toxic gas emitted industrially is sulfur dioxide, chiefly in flue gases from combustion. Another kind of potentially toxic industrial pollutants is a group of fluorides, both in gaseous and particulate form. The toxic gas, carbon monoxide, is emitted from some industrial operations but in nowhere near the amounts emitted in vehicular exhaust. In the area of toxic substances, public health and industrial personnel are having a difficult time because of the unknown possible chronic effects of long-time exposure to low concentrations.

5. *Photochemical Pollutants*

Photochemical smog, of the type commonly encountered in Los Angeles and much less frequently elsewhere, results from a photosensitized atmospheric reaction between reactive hydrocarbons (chiefly olefins), perhaps certain organic solvents, and oxides of nitrogen. The chief source of olefinic hydrocarbons and nitrogen oxides is motor vehicle exhaust. This is an area where many research

projects are coming to fruition and the rate of progress is increasing.

A variety of control methods are used by industry to reduce emissions to the point where air quality is acceptable. Occasionally, the value of material recovered will pay in whole or in part for recovery equipment and its operating costs. In the vast majority of cases, control equipment which must be installed to prevent or greatly reduce emissions represents a capital investment and extra operating costs over and above those of an uncontrolled process. For an equitable solution the cost of control must be weighed against the frequency, severity, and nature of the effect caused by the pollutant. The air pollution problems of old plants are far more difficult to solve than those of new plants. Consideration should be given to accelerated amortization allowances for non-revenue-producing control equipment. Progress is being made in clearing the air of industrial waste, but we still have a long way to go.

The 15 largest conventional steam-electric generating stations in service in 1962 varied from approximately 1,000 megawatts to almost 1,500 megawatts in a single station in one location. The principal new factor affecting air pollution from these stations has been the rapid adoption of larger individual units and larger stations. In the past decade, there has been a growing awareness of the need to disperse more effectively the gaseous products of combustion from central generating stations. This is entirely aside from the mandatory restrictions in codes covering particulate matter in the gaseous effluent.

In any given community, it is difficult to establish the size of a central generating station burning coal or oil at which the emission of pollutants to the atmosphere may be anticipated to have any adverse effect. This depends on meteorological conditions in the area, geographical surroundings such as hills and bodies of water, the nature of the fuel burned, the type of combustion and furnace equipment with which the station is equipped, and the degree to which the area is heavily populated and industrialized.

With electrical loads doubling approximately every 10 years, there is reason to believe that by 1980, unit and station sizes will become substantially larger. In fact, it appears likely that 4,000- to 5,000-megawatt stations may be in operation by 1980. However, it should be recognized that the potential air pollution problems of such extra-large generating stations burning coal or oil cannot be fully evaluated at the present time. Furthermore, the nature of the problem is such that it must be approached by progressive experience extending over a period of years. The possibility that such extra-large stations may be constructed is sufficient reason to intensify studies of methods and techniques related to this potential problem.

Undoubtedly, these extra-large generating units and stations will result in a continuing upward trend in stack heights, although the stack height at any particular plant site depends on a number of factors. However, significantly higher stacks cannot be taken for granted, because aeronautical factors related to air safety must be taken into account. Because of these aeronautical factors, it is not unusual for plants now in operation to have stacks lower than would otherwise have been desirable.

Industrial pollution is only one facet of community air pollution. The "homes" that make up a municipality range from single-family dwellings through multiple-family apartment buildings to, and including, hotels. Operations concerned with heating these homes and disposing of refuse from them constitute their principal contribution to air pollution. A number of other home-connected operations often contribute to community air pollution from time to time, including emissions of odors and vapors, and construction or demolition operations. All of the cited home sources of air pollution are amenable to adequate control. Exercise of forethought and the practice of commonsense preventive measures will usually reduce these emissions to tolerable levels.

Some special problems arise in mixed-occupancy buildings which have commercial and residential operations under one roof. Here again, adequate control can be planned and executed in almost every case.

Boiler-furnace units have received so much competent engineering attention that there is little excuse for their presenting a problem these days. However, when maintenance is neglected or operation is slipshod, the benefits of good engineering design often are lost.

Incineration technology has made substantial advances, but the varied nature of home, commercial, and industrial refuse often defies nuisance-free burning on a practical scale in available municipal-type incinerators. Here is an area that needs further attention.

Those responsible for emitting significant air pollution often are unaware of it. When properly apprised, such persons generally are willing to take corrective steps if practical, economic corrective measures are known. The control official must educate those he serves in the need for control and the means of accomplishing it.

A special problem area has arisen in many large cities; that is, the municipality may, under one of its agencies, engage in operations that create significant air pollution and, under another of its agencies, have a responsibility for abating this pollution. Differences of opinion regarding responsibility and "jurisdiction" can make for sticky situations or lead to an impasse. Forthright analysis of the problem by a top-level municipal administrator and adoption of decisive steps for correction are invariably indicated.

A 1961 survey revealed that about 120 urban areas of more than 50,000 population had community air pollution control programs. In most, the primary emphasis was on abatement of emissions from major industrial sources, refuse disposal, and materials-salvage operations. It is now apparent that there has been relative neglect of multiple lesser sources more closely identified with the private lives of the individual. In the aggregate, these emissions are invariably a substantial factor when community air pollution presents a problem; their relative importance must necessarily increase as other potentially concentrated sources of pollutants are brought under effective control.

An assessment of municipal levels of control effort for a recent 10-year period indicated that we are actually losing ground in our fight against air pollution; the "average community" has not increased its abatement efforts in proportion to its growth. It appears that the financing of adequate municipal programs is a critical problem.

Assuming that a community has an air pollution problem and an informed citizenry seeking a solution, the financing of an effective program is usually difficult. Hence, a new approach to program funding should be helpful. Some desirable elements of such an approach seem clear: the source of revenue should relate to the air pollution problem and it should provide for increase in proportion to growth of need for control.

During the open discussion, it was pointed out that municipal officials and municipal planners should employ available knowledge and give consideration to minimizing the undesirable localized effects of "uncontrollable air pollution." There is also a need to revise thinking on industrial zoning regulations. Outdated lists of so-called "obnoxious industries" are used in an almost arbitrary manner in zoning procedures. The significant advances in industrial air pollution control techniques should be recognized when the allocation of industrial sites is being considered.

It was agreed that it is difficult, and in most cases impossible, to place an economic value on the esthetic effects of air pollution. The balancing of equities to arrive at a decision with respect to the degree of air pollution control desired involves not only economic and scientific considerations but also sociological evaluations.

The removal of contaminants from stack gases, without lowering stack gas temperatures, is desirable. The discharge temperature of the gases is an important factor in diffusion considerations. Current research projects on the "dry scrubbing" of stack gases were reviewed. These and similar techniques appear technologically feasible, but their economics is yet to be established.

Throughout this panel session and in the open discussion ran the following themes: the sources of air pollution are numerous, the problems of identification and measurement of the effects and control of pollutants range from simple to very complex, economics is vitally important, considerable progress has been made in the past decade, and further progress will be made.

The rate of increase in our knowledge of the effects and control of air pollution is rapidly accelerating. Indications are that the people responsible for air pollution control are using this information as it becomes available.

Report of the Chairman, Panel C
HEALTH CONSIDERATIONS

WILLIAM S. SPICER, JR.

Severe smog episodes which cause an increase in illness and death, such as that recently experienced in London, and community outbreaks of an asthma-like illness which have occurred in certain geographic locations, while illustrative of the disaster potential of air pollution, are unusual and infrequent. Undue attention given to such conspicuous events often serves to obscure the basic health problems associated with environmental factors. In addition, although the British have done extensive clinical, epidemiological, and pathological studies and we have profited immeasurably from their experience, it is apparent to most investigators in this country that our problems differ from theirs. Consequently, the panel on "Health Considerations" appropriately focused its attention on the more common and important acute and long-term effects of air pollution on respiratory health in the United States.

In discussing the relationship of air pollution to respiratory health, we are dealing with a complex of variable factors. With the exception of irritation to the eyes and nose and the finding of an increased frequency of upper respiratory infections, for example, "colds" and "flu," with increased pollution levels, our present knowledge is confined primarily to the diseases of the lungs. Specifically we are talking about bronchogenic carcinoma, the pneumoconiosis or dust diseases of the lung, the huge problem of the chronic bronchitis-emphysema syndrome, so-called intrinsic asthma, and other more obscure lung diseases. We recognize, but fail to understand fully, the mechanism of individual host susceptibility. Evidence has been presented that the susceptible human being by his choice of residence, that is, urban versus rural, and including climatic and topographic variables, exposes himself to environments with differing respiratory disease potentials as related to the type and severity of the eventual disease. In topographically similar locations, the existing meteorological conditions and the type of pollution are major factors in determining the amount of damage which may occur. Other important considerations include the type of housing, the mode of heating, the forms of public transportation, and the nature of in-office or in-plant ventilation in industrial production.

A remarkable unanimity of opinion was expressed by the participants of Panel C concerning the complexity of the relationship between air pollution and respiratory health. At first glance, the realization of this complexity and the multifaceted investigative approach to the problem would seem to lead to considerable confusion. The classical procedure for the early investigations of the etiology of a given disease assumes a one-agent to one-disease relationship. Where necessary, or as new methods or observations become available, this simple one-to-one relationship is broadened. That this is not the case at our present early stage of understanding of the effects of our environment upon respiratory health was amply demonstrated by the panel yesterday. On the basis of investigations already completed or in progress, the panel repeatedly emphasized the concept of interaction between various agents.

The chronic respiratory diseases develop slowly over a number of years. Generally, they have their inception in the ages between 20 and 30; they usually become clinically evident after the age of 40; and they may become disabling soon after the age of 50. This slow progression is apparently caused by a wide variety of inhaled irritants

Particulate matter in a size of less than 5 microns increases the airway resistance of normal individuals as well as that of those with respiratory disease. The products of both industrial and automotive combustion and of cigarette smoke can temporarily paralyze the cilia and depress the self-cleansing mechanism of the respiratory tree, thus allowing the accumulation of irritants, including carcinogens. Adsorption of such toxic substances as sulfur dioxide on small particulates is another mechanism of delivering toxic materials to certain areas of the respiratory epithelium. Combinations of these two actions are extremely likely in the urban smoker and possibly cause additive damage. It matters little to the lung which particular substance disrupts its epithelial lining. Thus, different toxic or irritating substances may appear at daily or hourly intervals or with each breath, and can produce similar damage. Epidemiologic studies have shown that the frequency of acute viral respiratory infections is significantly higher in polluted areas. Such viral infections have a disruptive effect on the lung tissue.

Exposure of mice to aerosols of cancer-inducing hydrocarbons alone or to influenza viruses alone has uniformly failed to induce human-type lung cancer. However, exposure to these two different agents in combination has resulted in the production of this specific human-type pulmonary neoplasm. Numerous agents which can cause cancer in laboratory animals are found in our urban atmospheres. The concentrations of these substances, however, are much lower than those necessary to produce cancer in mice. On the other hand, noncarcinogenic hydrocarbons, also present in these atmospheres, have been found to accelerate the tumor production of purified cancer-inducing substances such as benzo(a)pyrene. Conversely, inhibitory or anticarcinogenic substances may also be found in the urban air. This might suggest an interesting tug of war between these carcinogenic and noncarcinogenic substances. It certainly does suggest a complex problem.

That repeated insults to the lung and airways are fact and not fiction is further supported by daily lung function studies of groups of individuals residing in the same urban environment. Not only patients with moderate respiratory disease but also normal young people are literally on a pulmonary physiological "yo-yo," for it has been shown that and patients show fluctuations in the same direction at the same time. Not only does this, in itself, suggest that they are reacting to a common factor in their environment, but also statistically significant correlations between their respiratory function and the air pollution levels are present. These correlations are not for the same pollutants or for the same combinations of environmental factors in different individuals, nor do they have similar time-dosage relationship. Furthermore, the concentrations of pollutants to which these subjects appear to react is far below what we now consider to be dangerous. The normal young adult shows less fluctuation than the individual with moderate disease. The severely diseased individual also varies less, but his variations are at the lower end of the respiratory function scale, alternating between bad and very bad. However, the effect of these slight physiological changes on the severely disabled person is very great clinically. Once the disease is present, the sensitivity of the individual to pollutants, as manifested by the increased degree of respiratory function change, increases, possibly suggesting an additive effect. These changes alone, or in combination with repeated respiratory infections, result in frequent clinical exacerbations of disease.

Epidemiologic studies in Britain have repeatedly shown that individuals residing or working in a polluted environment have a much greater prevalence of chronic obstructive airway disease than those in less polluted areas. This difference in prevalence is apparent in the 25-to-34 age group for the most polluted areas. British children from heavily polluted areas below the age of 11, where cigarette smoking is not a complicating factor, have been found to have significantly lower respiratory measurements than those from cleaner areas. Evidence is available which shows greater prevalence of chronic respiratory disease in urban dwellers than in rural dwellers. An effect of urbanization on lung cancer rates in this country has also been found, but it appears to be small. Urban-rural differences are less apparent in smokers than in nonsmokers.

Recently, a British-American team utilizing standard British criteria found a 3-percent prevalence rate of chronic bronchitis in a group of workers with similar occupations from Washington, Baltimore, and New York. The rate in comparable British workers, as determined by the same kind of group and with the same criteria, was 10 percent, or more

than three times as great. In the British patients, symptoms of cough and the production of sputum correlated closely with the degree of cigarette smoking, while irreversible lung disease correlated best with pollution levels. The same relative relationship holds for the prevalence of bronchogenic carcinoma in the two countries. However, this should afford us small consolation, as bronchogenic carcinoma is the most common cancer in males in the United States and recently has been showing an annual logarithmic increase. It seems highly unlikely that our male population looks upon this as a race or will soon consider the act of spitting blood as a status symbol.

A 22-percent prevalence of chronic bronchitis and a 39-percent prevalence of all nonspecific respiratory disease in males over 25 has recently been reported in a small community in this country. A 22-percent prevalence of chronic respiratory disease in males of ages 40 through 59 has recently been found in a New Jersey housing project. These two surveys include milder cases than the survey reported in the previous paragraph.

When we consider chronic respiratory disease we must remember that we are dealing with a situation similar to an iceberg. This group of diseases progresses slowly over a span of 30 years from inception to overt disease. There is an early stage of this process wherein certain physiologic abnormalities can be demonstrated by sensitive measurements. However, there remains sufficient respiratory reserve to prevent the subject from realizing that he is sick. As this respiratory reserve progressively shrinks, a point is reached in many when it becomes obvious that disease is present. Frequently, increased cough or acute respiratory illnesses may subtly or abruptly signal the onset of the clinical phase. Shortness of breath may be the next manifestation. At the present time, many undoubtedly complete their lifespan before shortness of breath becomes apparent. We should consider, particularly in the light of both our increasing urbanization and increasing air pollution, that any decrease in the age of the inception of the disease, or more importantly, increase in the rate of progression of the disease, may not become evident for 10 tc years.

The evidence presented has evolved from ma laboratory and epidemiological studies. In the fu ture we must look forward to expanded medical research in this field. At present we have no real human basis for air-quality criteria and must do the type of studies designed to give us these criteria. While we have considerable work to do with various animal species, the ultimate test animal is man. He must be more continuously evaluated in his natural environment; that is, at work and in his home as well as when he is breathing the community air. Industrial investigators must place their main emphasis on the determination of the long-term effects of low levels of various substances. Inevitably, the exposure of volunteers to controlled synthetic atmospheres, in an effort to duplicate the naturally occurring pollution, must be undertaken.

The great danger in summarizing the conclusions of this panel is that in emphasizing the complexity of the situation, individuals will make complexity synonymous with lack of sufficient evidence of a relationship between air pollution and a serious health problem. This is not so. It would be a mistake to leave this conference with the impression that there is insufficient evidence for action—now. The evidence that air pollution contributes to the pathogenesis of chronic respiratory diseases is overwhelming. The classical concept of one agent being responsible for one disease is, and has been for that matter, an investigational convenience. At the beginning of this conference, Dr. Terry emphasized that the demonstration of a cause-and-effect, or one-to-one, relationship is an unrealistic approach to this problem. The multidisciplinary efforts which have demonstrated the interactions of various chemical irritants, of infectious agents, and of carcinogenic substances, together with meteorological factors, as affecting human respiratory health are entirely what should be expected of complex man in his complex environment. Neither these complicated interactions nor the variabilities of the types of pollution of different communities should be used to camouflage the need for action.

Report of the Chairman, Panel D
AGRICULTURAL, NATURAL RESOURCE, AND ECONOMIC CONSIDERATIONS

JOHN T. MIDDLETON

Air is a natural resource vital to man. Its composition directly affects man and the community in which he lives, the foods which nourish him, the forests which supply him with building materials and other useful products, the lands which are an integral part of his economy, and the recreational areas which enrich his well-being. Man's dependence upon the air resource requires that it be protected from contamination and conserved for society. Increases in population, trends toward further urbanization, growth of industry, and advances in industrial technology, all place increased demands upon our limited air resource. These demands have resulted in the deterioration of air by adding a variety of industrial, motor vehicle, and domestic contaminants. This is manifested by irritation to the senses, reduction in visibility, and damage to animals, vegetation, and property.

The classic air pollutants, smoke, dust, fluorides, sulfur dioxide, and odors, still plague us. Many of the dramatic specific emission sources have been significantly reduced through controls, but this improvement is partly offset by the increase in the number of contaminant sources. Today we must also be concerned with the photochemical air pollutant reactions occurring in the air over our metropolitan areas and adjacent farm, forest, and recreational lands. The chemical composition of the air mass fluctuates with both time and space. Variations in pollutant concentrations depend on meteorological conditions, the rate of pollutant input, and the nature of the materials from pollution sources, as well as light intensity, moisture, and temperature. The chemical composition of an air mass varies as it moves from place to place and as the chemical reactions proceed. New contaminants pumped into the air mass at varying rates from motor vehicles and stationary sources replenish the supply of contaminants and keep the reaction going.

These photochemical reactions occur between organic substances, largely hydrocarbons, and nitrogen oxides to produce ozone, peroxyacyl nitrates, aldehydes, and many other products. Although some of the specific source pollutants are in themselves responsible for effects on plants, animals, and materials as well as on weather and visibility, a number of the products of these chemical reactions which occur in the air also cause injurious effects.

This serious new air pollution threat to cultivated crops and wildland products has developed in the last two decades. The pollutants in photochemical air pollution are no longer restricted to California where they were first seen, but are found in 27 States, the District of Columbia, Mexico, and Canada. One of these products, ozone, is damaging many sensitive plant species. Another oxidant produced in the polluted air mass, peroxyacetyl nitrate, also damages many crop plants, yet in a way different from that of ozone. These pollutants at concentrations of as little as a tenth of a part per million not only injure leaves, but also decrease photosynthesis, increase respiration, cause leaves to drop, and result in slow growth and lower yields.

Fortunately, sulfur dioxide is no longer killing vegetation on as grand a scale as it did early in the century; today it is a problem mainly around a large number of small emission sources throughout the country.

Fluorides damage fiber, food, forage, and forest crops, as well as livestock in many States. The number of gaseous and particulate industrial fluo-

ride sources has increased in recent years and were it not for improved fluoride emission control this contaminant would be of great concern to agriculture.

The agricultural losses resulting from the adverse effects of all of the presently recognized pollutants have been estimated to amount to hundreds of millions of dollars a year in crop destruction, yield reduction, and quality diminution.

The total cost of air pollution to the community may be divided into the cost of losses suffered as a result of pollution and the cost of controlling air pollution. A number of types of air pollution damage have been described, and from time to time estimates have been made of the economic losses due to these damages. However, the subtlety of air pollution damage makes its cost difficult to estimate with any substantial degree of accuracy. The costs of control can be divided into several groups such as expenditures by government, industry, and the individual, and estimates for these have been made. If damage and control cost estimates could be made with sufficient accuracy, they could be highly useful in assessing the value of air pollution control measures, as well as the need for additional measures. Decisions on air pollution control are essentially judgments which require that all known effects be considered in terms of their total impact on the community.

Damage to materials, vegetation, or livestock is essentially an economic matter, but where human health is concerned, opinions differ sharply. Although human illness and death resulting from air pollution are occasionally reported, opinions differ regarding the desirability of translating the impact of these into economic terms. Effects on human health may be expressed in economic terms in some contexts for the sole purpose of giving them their correct relative economic weight. Man's personal needs and desires may at times override economic considerations. On the basis of estimates currently available it appears quite clear that the annual cost of air pollution damage greatly exceeds the annual cost of all control measures currently being exercised. Since air pollution threatens man's enjoyment of his resources, the development of air pollution abatement programs requires that the quality of air desired be defined and that the movement of the polluted air mass over cities and farms be understood.

Regional planning on the basis of airsheds, similar to that of watersheds, is long overdue. Knowledge of weather factors permits the tracing of airsheds defined in terms of meteorology and topography on maps which already record land use, population densities, traffic flows, industrial site locations, and other demographic data. For each such airshed the overall natural dilution capacity of air may be estimated, and studied in relation to the amount and kind of contaminants likely to be produced within the district or received from external sources. Local variations within the airshed are also significant. Enough is now known to make the calculation of regional air dilution capacities feasible and the use of the airshed concept in land-use planning practicable.

Significant reduction in levels of air pollution must take into account all of the factors affecting atmospheric contamination, including rapid transit, freeway and industrial site location, and redesigning home-job and home-recreation relationships to reduce travel. Dispersal of employment opportunities into clearly defined subregional cities with suitable homes and other facilities available close by would also improve the visual environment, reduce costs of municipal services, and tend to rationalize the distribution of taxes. Subcities of 250,000 to 1 million could support their own junior colleges, commercial and professional services, and cultural and social activities, and enhance their attractiveness by being surrounded and intruded by woods and ranchlands reserved as permanent open space. A regionwide transportation system could coordinate all types of transportation, reserving costly rapid transit for those few areas where local conditions present great difficulty to private transportation. The massive metropolitan crisscross commuting, with its long tedious rides to work and back, to recreation and back—would be cut and the chief source of air pollution reduced.

Obsolescence leads us to destroy so much of our cities that great possibilities for improved urban design exist in our renewal programs.

These deliberations indicate that an expansion of air pollution control activities is desirable and necessary, now, within both government and industry. They also indicate that in the long run a significant reduction in air pollution may be achieved by sound planning for metropolitan area growth. They further indicate that the extent of air pollution control must be related to soundly defined air quality standards used on a regional airshed basis.

Report of the Chairman, Panel E
APPLYING OUR MEASURING AND MONITORING KNOW-HOW

GLENN R. HILST

I. *Measuring and Monitoring in the Context of the Air Pollution Problem*

It is perhaps a measure of the sophistication of our present-day approach to the problem of air pollution that the participants in this panel found it necessary to place the role of measuring and monitoring within the perspective of the whole problem of air pollution before discussing this particular aspect in depth. Most assuredly, air pollution is a complex problem, made up of many scientific, medical, economic, sociological, and legal aspects. Consideration of how and where we may apply our measuring and monitoring know-how in the amelioration of air pollution cannot be viewed solely as a separate and self-sufficient quest. Rather, it must be approached in the context of complicating and frequently competitive considerations of other facets of the problem as well.

Recognizing this, it may still be said that measuring and monitoring activities are today central to our approach to air pollution problems on all scales. In fact, the physical synthesis of the whole problem of air pollution is today most nearly found in the data which are gathered in any well-planned measurement and monitoring program. Such measurements include human perception or the effects of pollutants on vegetation. It is these data which specify the amount and variation of various airborne materials, and, when analyzed in terms of the effects of these materials on their potential receptors, tell us whether or not we have an air pollution problem and, if so, its severity. Similarly, these data, taken in conjunction with meteorological measurements, provide the first indications of the source of air pollutants and point the finger, as it were, at those facets of human activity responsible for our air pollution.

In a very real sense then, measuring and monitoring activities are the alpha and the omega of the air pollution problem. To the results of these activities we direct the basic questions, "What are our real air pollution problems?" and "How well have we solved these problems?" And, in between, these data guide our work on the component parts of the problem in the areas of source control, atmospheric dispersion, and receptor effects.

II. *Applying Our Measuring and Monitoring Know-How*

Given this central role in the air pollution problem, how do we set about acquiring and using information on the distribution and variability of pollution levels? What kinds and amounts of data do we need from our air pollution measurement systems? How do we analyze, interpret, and use these data? How do we balance the need for information against the cost of acquiring that information?

In considering these questions, the first general conclusion of the panel is that any measurement and monitoring program must be tailored to the problem at hand. This may at first glance appear paradoxical, calling as it does for knowledge of the problem in order to design a system capable of specifying the problem. The paradox is resolved, however, if we recognize that some knowledge of the probable types of contaminants which should be measured exists and an *a priori* assessment of likely distributions of pollutants can be made from a general knowledge of source distributions, topography, and meteorological conditions. An initial

measurements system design can be derived from this information, supplied by the specialists in (1) source strengths and materials, (2) atmospheric dispersion, and (3) receptor effects, in the form of system specifications. Then, of course, this measurement system must be considered evolutionary in character, subject to change on the basis of its own information and in response to new problems not accounted for in the initial design. Mr. Maneri has provided excellent examples of this approach in his "discussion" of Mr. Raymond Smith's paper.

In tailoring a measurements system to a particular locality or problem, we must ask, "What are the objectives of this program of measurements?" The objectives may range from a nationwide comparison of urban pollution levels to a detailed analysis of all facets of air pollution generation and distribution in a single restricted area. In either case the information necessary to design a system which can meet the objective can be found in today's know-how. What we must remember, but frequently forget, is that a system designed to meet one objective cannot be expected to meet other objectives, and may in fact totally mislead us if misused in this way.

The second general conclusion of the panel is that, while it is incomplete, there is adequate know-how in the areas of sampling and analysis equipment and methods to enable us to begin to cope significantly with air pollution problems. Further development in these areas is called for and will be needed as new materials are introduced.

Less expensive, more rugged, more reliable, and more fully automated observation systems are clearly required, particularly for a small community's use. The cost of sampling and analysis systems and in data reduction and handling will continue to be a problem, but it is one which must be faced. However, as pointed out by Mr. Smith in his review of the use of the measurements and monitoring system in Philadelphia, it is not necessary to wait for the millennium of complete and exhaustive measurements. Partial information, used correctly, leads to partial solutions which are useful and frequently sufficient to guard against the major menace of air pollution to health and well-being.

III. *Responsibility for Measuring and Monitoring Activities*

From the foregoing discussion we may conclude that much of the know-how of measuring and monitoring necessary to the control of air pollution levels is available to us. Uncertainties of receptor-pollutant interactions and of time and space variability of pollutant levels cloud this picture, but are not so great as to seriously cripple our effort. Costs, not technological know-how, are our most frequent stumbling block.

However, implicit in all of this panel's considerations is the underlying realization that the problem of air pollution is a very complex mixture of scientific and social problems, and the concerted efforts of specialists in these multiple disciplines must be properly used in any successful approach to measuring and monitoring activities. The "cookbook" for this activity cannot be written, or, if properly written, could be understood only by the experts who composed it.

In view of this requirement for expert guidance, whether for a local air pollution problem or a national program, and realizing that air pollution is no respecter of geographical boundaries, to whom should the responsibility for measuring and monitoring activities be assigned? Professor Hendrickson concludes that there can be no single level of government or one private agency to which this responsibility can be assigned.

Within the general philosophy that responsibility should be assigned to the lowest organizational level capable of doing the job, considerations of scope and cost, recurring versus one-shot efforts, and political jurisdiction must be included. Data processing, analysis, and dissemination are also part of this program and generally call for a centralized facility.

The role of the individual citizen who contributes to air pollution, suffers its consequences, and foots the bill for both the damages occasioned by air pollution and the costs incurred in controlling it, cannot be neglected. But he cannot be assigned responsibility for monitoring air pollution beyond his control. Similarly, industries have a responsibility for monitoring their own contributions to air pollution. Beyond this, measuring and monitoring efforts are in the public domain and for the public welfare. It is, therefore, quite logical to assign responsibility for this activity to that level of government which has the technological know-how, jurisdictional authority, and resources to successfully accomplish the work required. The decision as to precisely which governmental agency meets these requirements is another which must be made for individual problems.

A problem noted strongly by this panel concerns the frequent lack of air pollution measurement information exchange. This situation, whether due to unnecessary classification of data or to simple lack of interest and facilities for processing and disseminating the information, is deplorable and should be corrected by every means available.

IV. *Conclusion*

In conclusion, we have a very considerable advanced know-how in the measurement and monitoring of air pollution. We cannot be complacent. But we are well equipped now in this central activity, equipped to do necessary things to guarantee clean air today.

Report of the Chairman, Panel F

APPLYING OUR CONTROL EQUIPMENT AND METEOROLOGICAL CONTROL KNOW-HOW

MELVIN W. FIRST

There appears to be reasonable agreement that existing air pollution control know-how is being widely used for the control of most recognized poisons to prevent concentrations in the atmosphere which cause specific acute illnesses. Conversely, our knowledge of the necessary control know-how is incomplete for nonspecific pollutants which may (1) produce degenerative or chronic health effects, (2) result in property damage, or (3) cause nuisances. Even when adequate technical know-how exists, the installation of controls is often difficult to justify economically. This state of affairs is understandable, as scientific investigation of these problems is scarcely a decade old and the epidemiological and toxicological factors are only partially understood. Specifically, medical statistics in many instances are inadequate to explain the epidemiological factors underlying a sound air pollution abatement program.

There are divergent opinions on what must be done now about air pollution control; on how rapidly it must be done; and on the matter of its financing. On the one hand, some enforcement officials have told us that most sources of air pollutants should be controlled immediately; on the other, industrial representatives, with equal sincerity, have told us that we must justify the need for control and, in some cases, wait for the technology of air pollution to catch up with present-day needs. It seems clear that when more and better meteorological and source emission information pertaining to the dispersion of pollutants in the atmosphere and their ultimate disposition is made available to air pollution control engineers, and when more exact information has been developed on the toxicological effects of a number of airborne substances, a large area of disagreement and controversy will have been eliminated. However, the economic factors influencing the application of control will not have been completely resolved.

With respect to the application of meteorologic know-how in the control of air pollution, we have heard that important advances have been made during the past few years (1) in understanding the manner in which stack effluents disperse in the atmosphere, (2) in charting the effects of terrain irregularities and manmade structures on micrometeorological patterns, and (3) in predicting from models pollutant concentrations in the atmosphere in the vicinity of emitting sources. Practical meteorological studies of transport and dispersion have been, and continue to be, applied successfully by an increasing number of public and private agencies. The principal needs for better utilization of these techniques are (1) an interdisciplinary approach, and (2) a greater number of specially trained meteorologists. In addition, it seems clear that we need simplified techniques which will permit the general practitioner of air pollution control, be he public official or industrial employee, to handle moderately complex problems in a routine manner.

We have made a good start toward an understanding of the way in which meteorological phenomena affect the dispersion and elimination of atmospheric pollution over a large region, but only a start. Management of the air resources over heavily populated, heavily traveled, and heavily industrialized areas seems, today, to be proceeding on an intuitive basis because of a lack of satisfactory knowledge of air purification by natural processes.

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and immediate problems with the resources now at our command, we must institute and vigorously pursue a long-range policy designed to—

(1) Develop a means for exchanging control experiences, both good and bad, pertaining to engineering applications and methods;

(2) Train more people in the basic scientific, meteorological, and engineering knowledge pertaining to air pollution control and motivate them, by increased compensation and professional satisfactions, to make a lifelong career of this profession; and

(3) Increase opportunities for broad-gaged interdisciplinary studies of air pollution control methods. This approach appears to provide a needed opportunity for law enforcement officials, professionals representing industry, and research groups engaged in the study of air pollution, to gain valuable insight into all aspects of the application of control know-how by purposeful cooperation. Besides the technical benefits to be derived from the work of a large and varied group of interested specialists, there is some hope that this type of activity will lead to a better mutual understanding of each group's special problems and responsibilities.

Report of the Chairman, Panel G
APPLYING OUR LEGISLATIVE AND REGULATORY KNOW-HOW

ERWIN E. SCHULZE

National concern over the problem of air pollution has increased each year since the enactment of Public Law 159 in 1955. It seems clear that there will be enhanced public concern over this subject in the years to come. This concern has caused a reevaluation by society of the social advantage or disadvantage of air pollution. This reevaluation, reflected as it is in the attitudes and actions of our legislative councils, will have a comparable reflection in the judgments and opinions of our courts and the actions of our regulatory officials.

There appears to be general agreement that the law has upheld, or will uphold, each and every reasonable attempt to control and reduce emissions into the atmosphere. In very general terms then, the law provides us with sufficient legal weapons with which to engage in the battle of air pollution control. There is disagreement on the question of when, how, and to what degree these legal tools should be utilized. Important private and public interests are concerned with the resolution of this problem and it seems clear that the reconciliation of these interests, which sometimes seem to be in conflict, should not necessarily be approached solely on the basis of determining the furthermost extent of permissible governmental action without a clear demonstration of the need for such extreme action.

The mechanics of legislative and regulatory action was presented by Harold W. Kennedy, county counsel for Los Angeles County, Calif. In his opening statement Mr. Kennedy pleads for effective air pollution regulation in the place of voluntary programs. Effective regulation, he says, does not require perfect knowledge and he cites the example of the success of the Los Angeles County air pollution control program, which set about to abate all emissions. Economic progress of the area has not been impeded and the rules and regulations adopted on the foregoing premise have successfully stood the test in court.

In a scholarly review Mr. Kennedy details the legal bases for the control of emission of air contaminants. He points out that, in his experience, the permit system has been shown to be the most effective and positive weapon in the arsenal of air pollution control officers and that a criminal penalty for violation should be attached to the rules or ordinances regulating air pollution. Self-regulating plans are generally of a temporary nature and, in his opinion, evaporate when the pressure is taken off. He acknowledges that the injunctive procedure is a fine legal tool when dealing with a large and continuous violation. However, Mr. Kennedy believes the most effective day-to-day enforcement places reliance upon the possibility of a criminal penalty.

Frank L. Seamans, attorney-at-law, Pittsburgh, takes issue with the thesis presented by Mr. Kennedy that air pollution control regulation and enforcement should be commenced and vigorously pursued before, and even though, the problem has not been so analyzed, investigated, and researched that the precise aim or goal of the regulation has been determined.

Mr. Seamans believes that the two most important pillars of legal structure through which air pollution abatement is to be achieved are: first, a law which will encourage the full utilization of technical knowledge, and second, a law which is designed to give industry encouragement and authority to take

responsibility for achieving abatement. He urges caution in the establishment of emission limits and suggests that such limits should be established only after careful scientific study.

"The Role To Be Played by Local and State Government" was cast by P. W. Purdom, Director of Environmental Health, Philadelphia. Mr. Purdom opens with the observation that voluntary efforts of industry to curb air pollution are laudable and should be encouraged. As a basic premise, however, he believes that in a competitive market, complete reliance on voluntary effort is unfair since the worst polluter may be avoiding the cost of air pollution control, thereby giving his product a price advantage. A fundamental premise of air pollution control measures is that they be based upon need as developed through adequate information. He points out that communities have individual characteristics and that control programs should not be copied without due consideration of such differences.

In making the assignment of primary responsibility for air pollution control, he states a general principle that control of emissions from specific sources can best be accomplished at the lowest level of government capable of effective action. In practice, this means that the area of operations must be of sufficient size and of such characteristics that the control of sources of emission within the area will substantially eliminate air pollution from the area. Also, the coverage must rest on a population and economic base capable of financially supporting a competent staff and the required services.

Mr. Purdom adheres to the premise that control measures need not await the establishment of defi-

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velop guidelines in dealing with the interjurisdictional air pollution problem. Mr. Fitzpatrick expresses the view that local programs will be materially aided by the establishment of quantitative relationships between air pollution and public health. He also stressed the need for further Federal technical assistance to local programs.

From the floor during the open discussion there was general agreement and emphasis on the desirability of local control programs. This is interesting because there was also general agreement of the panel members as to the desirability of this concept. Disagreement was expressed concerning Mr. Kennedy's views that permit systems are essential for control of air pollution and that sole reliance on injunctive proceedings is almost useless. There was

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Report of th
APPLYING OUR PUBLIC IN
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At the close of this morning's session by Panel D, Irving Michelson of the Consumers Union summed up the essence of that discussion in these words:

> Control is always a balance between the desire of obtaining as clean air as possible and the price the community is willing to pay for reaching this goal. A community will be willing to pay the necessary costs only when it is convinced that either the comfort and health of its inhabitants will be increased or their economic burdens will be eased. A key word here is "convinced" . . . and this implies an educational process.

That was really the purpose of this panel: to discuss the problems and means associated with the required educational process. The discussion began with Dean Seldes, who asserted that we must recognize that communication must always precede decision and action. He pointed out that to communicate we must both transmit and receive. To assure that what we transmit is received,

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Having defined the importance of the decision-maker and the extent to which his authority sphere conforms to the community air pollution configuration, the panel unanimously recognized the need to communicate with and to influence the community decision-maker in the cause of cleaner air . . . wherever we might find him. And so, we return to Dr. Rossi's argument that air pollution must be put into politics and must aggressively seek to influence governmental decisions.

To accomplish this goal, Dr. Rossi emphasized that we must recognize the existence of at least two major community "publics": the general public and the political elite, or decision-makers and influencers. In effect, he asserts we must rather clearly identify "whose ox is going to be gored" by the community air pollution control program, which individuals and groups are most affected by the problem and by the control program.

Effective communication involves more than a mass appeal to a mass audience using only the mass media. "Before a proposed change in a community can become an object around which the public opinion—pro or con—is formed, it must first come to the attention of the population in question, and second be given an interpretation which engages the ongoing values and attitudes of the population." Dr. Rossi concluded by emphasizing that "the process of public opinion formation is a group process and that the individual rarely is influenced by the mass media as a single atomized individual."

John Bebout picks up this point and asserts that it's time we got on with this job of informing and

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ity. Somehow, an agent of advocacy in the cause of clean air must be identified, and the solid techniques of information collection and transmittal must be utilized. John Bebout probably would argue that this is the job of State and National Governments, where a capacity and competence for doing the job already exists.

In any event, aggressive and intelligent air pollution public information and education activities must be viewed, not as the icing on the agency cake, not as an unnecessary frill, but as a condition of progress in the field of controlling air pollution. Its

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Robert L. Myers. I am certain that all of us who have participated in this conference have been challenged by the call to clear the air and encouraged by the many thoughtful approaches that are being directed toward the eventual solution to this problem. There were, however, numerous references to the fact that there is a long road ahead to the solution that we all seek. I submit that there is one additional approach which offers the potential of almost immediate solution to the problem for most Americans, since almost all human endeavor today is conducted within the confines of offices, or homes, or schools, or factories, or transportation vehicles. The application of recently developed as well as older control techniques to these occupied spaces can totally eliminate contamination in these spaces. These techniques remove and destroy the offensive matter, both particulates and gases, thus providing an improvement over even a clean, natural environment, since there is a simultaneous removal of natural dusts, pollens, and bacteria. I should like to suggest that consideration be given to this approach, both in the programs sponsored by the Department of Health, Education, and Welfare and in those which are seeking solutions on local levels. This approach does not conflict in any manner with, nor detract from, the long-range efforts to eliminate the necessity for such capsule control. However, it can be likened to our practice of purifying the water we bring into our homes, while still working toward the elimination of water pollution. While we cannot pipe clean air into our cities, we can pipe clean air into our homes, offices, and other places of habitation.

Richard M. Billings. I have taken a very active interest in all phases of this thought-provoking conference. One point, however, has bothered me throughout, and that is the implication that I—

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tive, the laws weak, and the efforts futile. A group of new leaders in business and local government came into positions of power and influence in the middle 1940's after the war and decided to tackle boldly the obstacles impeding Pittsburgh's rebirth, of which air pollution was perhaps the most formidable. To bring unity and a fresh vigorous approach to community problems, the Pittsburgh public and private leadership formed the Allegheny Conference on Community Development. Created in 1943 and chartered by the Commonwealth of Pennsylvania, the Allegheny conference is a nonprofit, privately financed citizens' organization which has spearheaded the resurgence of Pittsburgh and Allegheny County for almost 20 years. In the very beginning, the Allegheny conference realized that Pittsburgh had to solve the smoke problem if it was to develop and carry into reality a far-reaching redevelopment program that would assure the area's future. With aggressive support from the mayor and city council, combined with public support organized in the United Smoke Council, the citizens' action group, the city ordinance was made effective in October 1946, for industry. This ordinance was originally enacted in 1941 but World War II prevented its enforcement. In the period from October 1, 1946, to October 1, 1947, industry demonstrated convincingly what modern scientific methods could accomplish to reduce and eliminate smoke.

To prepare city residents for the enforcement of the ordinance's provisions applying to households, the United Smoke Council conducted a widespread public education program. On October 1, 1947, households within the city limits were

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members not only were familiar with the industrial processes and technology but also knew the economic feasibility of installing such devices. In addition to drafting the provisions of the ordinance, the advisory committee had the responsibility of recommending to the Board of Health of Allegheny County reasonable time schedules for the control of various sources of pollution from industrial processes.

The new Allegheny County smoke and air pollution control ordinance, embodying the best features of the city and county ordinances, became effective on October 1, 1960. The provisions are administered by the Bureau of Air Pollution Control of the Allegheny County Health Department. Today Pittsburgh and Allegheny County are recognized as among the cleanest urban-industrial centers in the United States. More than 150 official delegations from this country and abroad have visited the area to study the methods and beneficial effects of the communities' all-out smoke abatement program. The results are obvious. Through united community action and the wholehearted cooperation on the part of industry, the public, and local government, air pollution control was achieved and brought about the amazing results that Pittsburgh now enjoys. In 1940, before smoke control, the dustfall in Allegheny County was 60 tons per square mile per month. Twenty years later, in 1960, it was only 35 tons, and by 1970 it is expected to drop by another 15 tons. Visibility has been vastly improved by reducing smoke in the air. In 1940 there were 1,000 hours when downtown Pittsburgh visibility was less than three-quarters of a mile. By 1960, this was reduced to under 75 hours.

Without the interest and support of industry, the smoke control program would never have been accomplished and made such a striking success. Since the inauguration of smoke abatement in the

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In an attempt to set forth the philosophy of the chemical industry I should like to make the following points.

First, every scientist, in communicating to the public, should feel an obligation to make his reporting scientifically objective and accurate. His responsibility to the public and to other scientists requires no less.

Second, the public should be well informed and encouraged to preserve and protect the world in which it lives. Actually, industry has a selfish stake in this objective, since it is dependent for the successful running of its plants upon the health of its workers and the overall climate of the community in which its plants are located.

Since the beginning of its work on air pollution abatement, our MCA committee specializing in this area has been impressed with the community character of the problem and the logic of dealing with it on this basis. And we believe this view is now widely shared. As Surgeon General Terry said in his December 9 article in This Week Magazine, and I quote:

> No two communities have the same kind of pollution hazard. The sources will differ, and so will the kinds of effort required to control them. Basically, however, the need is for community action, with local government as the focal point. This will mean seeing to it that effective, sensible air pollution control regulations are adopted and enforced, and that an agency of government is created to carry out a control program.

In his talk before the conference yesterday, Congressman Kenneth Roberts also supported local handling when he said:

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nd evaluate industry's control efforts but also its xistence provided a guarantee that those responsi-le for other sources of air pollution would also be ncouraged to face up to their civic obligations.

This clearly proves that control and enforcement rograms have been successful at the local level, and hould be continued at that level, so that all ele-nents of the community, the enforcer and both the ndustrial and nonindustrial air polluters, could vork together for the most desirable solutions of heir common problems. The corollary of this is hat the Federal Government should not be author-zed by Congress to enter into the regulatory or nforcement field.

This is not to say that the Federal Government annot appropriately provide leadership through re-earch and advice. Industry certainly hopes that he Public Health Service and other Federal agen-ies will work harder than ever to develop knowl-edge that will lead to more effective and more eco-nomical air pollution control measures. Industry vants to cooperate. It has enough problems trying o make a living for all of us, so that it does not vant to fight anyone. I think it would be unfor-unate if industry's opposition to Federal Govern-ment enforcement of authority were interpreted as a fight by industry against the U.S. Public Health Service. As I have already indicated, the Federal Government can help greatly in our efforts to handle our problems by providing us with greater knowl-edge and understanding of these problems.

Industry has spent and is spending millions of dollars to install and operate equipment and de-vices to prevent air pollution. The huge indus-trial plants being built incorporate adequate and

Congress has extended the pre Pollution Act for another 2 years and we endorse this action.

Benjamin Linsky. In the contr dusts and droplets that reduce vi our ability to see lovely vistas, and trol of gases that are known to property and annoying to peopl these from the air we also obv great many other polluting mate otherwise get into our lungs. I k thing we all recognize but someti I believe there may have been a sli in a report—Panel F, specifically "toxicological factors." We all most any material at all, includi remember the old Mussolini wa considered toxicological. Even c in exaggerated quantities can be t my fear is that overemphasis on tors could lead to an attitude of we do some more health studies more control." Several of us ha industry groups and communities lution control activity by engagi but overly prolonged health studi

I have one more specific comme out whenever possible. I am loo tories where industries have sh moved out of a community becau air pollution control requiremen because of community air poll quirements—that might be too tion—but where community air ments and their costs were even a

charges, both into the water and into the air, has always been of uppermost priority with me. All of us in the mill are very proud of our accomplishments in this effort. Last year we were awarded first prize for the Northwest Pollution Control Association for the work we had done in reducing pollution to the atmosphere. This prize is doubly precious to us, since it was the first time any industry had been recognized for its effort by that association.

Relationships with the State Sanitary Authority have been maintained on the basis that each recognizes the other's responsibilities and duties. Work in reducing the waste discharges to the Mackenzie River has been recognized by the authority as being very satisfactory and at a steadily continuing rate of further reduction. Last summer we used strong condensates as irrigating water on pasture land, resulting in substantial further reduction and leading to a cooperative effort for next year among ourselves, Oregon State University, and the State Planning and Development Commission on use of waste industrial waters for irrigation purposes.

The ideas expressed in the papers presented here represent ideas and philosophies very useful to an operating manager. I should like to comment on two of the speeches I have heard.

Dr. Flemming's banquet address last night raised a major point with which I cannot agree, for reasons arising out of my own experiences in dealing with the State sanitary authority. It hurts a little to have to take issue with Dr. Flemming, who is now a brother Oregonian and who has occupied high Government positions, particularly as Secretary of Health, Education, and Welfare. I cannot agree with him that Federal participation should extend into the area of enforcement, because of my experiences in Oregon and in New York, and also because many of the experts who have talked in

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Theron G. Randolph. As a practicing allergist in the Chicago area, I agree with Dr. Sheldon's request as he stated it. We would participate wholeheartedly with such a movement. I should like to raise the question of determining the susceptible person so far as the chemical environment is concerned. This is an important point that was raised in many of the discussions in the course of this meeting, that the susceptible person is apparently more prone to reactions than the nonsusceptible. Now, one-third of my new patients have their chronic illnesses on the basis of susceptibility to various aspects of the so-called "chemical environment." The chemical environment includes not only outdoor air pollutants but also many others, including especially indoor chemical air pollutants, traceable in largest part to home gas appliances and chemically contaminated foods, especially foods containing spray residues.

Susceptibility is determined in my practice by hospitalizing patients suspected of being susceptible in specially engineered quarters. The patients are fasted on spring water only; they avoid all chemically derived drugs and cosmetics and all smoking; and they wear only natural fabrics in the course of this test. After a period of deprivation, common foods are returned one at a time and evaluated for the possibility of food allergy reactions. Then uncommon foods known to be chemically contaminated as purchased on the local market are returned and their cumulative effects appraised. Patients then return to their homes and their working

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outlook for emission reduction through engine modification or new powerplant design? What would you recommend to augment present activities in this field?

Meyer. This is a rather complex question. Industry is working on numerous possibilities. None has as yet reached a stage where any specific predictions are possible. We must recognize that any solution must also be acceptable in the marketplace. It would be possible today to build vehicles with acceptable emissions but with limited performance. Would the public accept them in the place of our present vehicles? I'm afraid I cannot give you at this time a specific answer. The search for a solution is going on both in industry and in the laboratories of universities and other independent research organizations. Greater stimulation of this search unquestionably would be useful, just as stimulation of improvements in mass transportation would be useful. In fact, I don't believe that all the possibilities that exist will have been given adequate attention until we at least find out whether or not there is any chance of solving the problem by other means than those we have so far examined.

Robert D. Cusumano. This question is of vital concern to both local and State air pollution control agencies. Mr. Schulze, could you describe how the proposed Federal program grants to States and communities would be used to expedite the application of available control methods and at the same time leave the States and communities free to decide for themselves to what extent they desire to control air pollution, in terms of the cost involved?

Schulze. With all deference, I should like to say

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an ideal or scientific standard of measurement. However, the fact remains that in the years gone by it has been most useful both to industry and to smoke officials. The Ringelmann chart, of course, was developed in the days when black effluents from chimneys were more or less prevalent. It was in this type of measurement that it has done its most good and been most useful.

There is work in progress on the development of a more scientific tool for this type of measurement. There is also study going on at the Taft Engineering Center right now covering this type of equipment, with the cost being borne on a 50–50 basis by the Edison Electric Institute and the Public Health Service. Now, in the so-called Model Smoke Ordinance of 1949 that was set up by the American Society of Mechanical Engineers, the weight of dust emitted from a stack was associated with gas bombs. This has been in process of review for some years now and a more recent study of the Committee on Air Pollution Control of this same engineering society is attempting to associate—and its preliminary form does associate—dust emission with B.t.u. input to the boiler furnace. There must, of course, be some connection between capacity, that is, size of equipment, and the regulations; otherwise air pollution control can set unrealistically low restrictions on size of industrial plants, be they powerplants or others. I might also refer Mr. Berry to the publications of the Air Pollution Control Association and more specifically to its very up-to-date publication on Atmospheric Pollution Problems of the Public Utility Industry prepared by the Association's DI–5 Technical Sub-

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ing projected installations to smaller sizes so that they would be more dispersed in location. Now this undoubtedly would affect the capital cost of the installation. It could also well result in higher operating cost per unit of output of the plants affected. I don't believe that control officials would want to be in this position, except perhaps where the effluent is known to be extremely toxic and where drastic action must be taken. Furthermore, even assuming that this type of emission standard could be developed on some equitable basis, it would appear to be a pretty difficult matter for the control officials to administer, because the principal concern today is more with the gases discharged than with the particulate matter discharged from these plants. The composition of these gases is very complex, and how we would go about establishing weight-rate standards for these different constituents, I wouldn't know offhand. It would be a most difficult job.

W. E. Tidmore. Dr. Hilst mentioned that costs can be stumbling blocks in the conduct of monitoring programs. I should like to ask him how cost can be lowered or kept in line.

Hilst. Well, let's recognize first of all, of course, that the cost of measuring and monitoring which I was discussing is just one of the costs involved in this problem. These costs are frequently substantial, so perhaps they should be viewed separately. There are several elements in these costs for measuring and monitoring. First, we have to acquire instrumentation, capital equipment, if you will; then it's necessary to maintain this equipment and keep it operating properly in the field under less than ideal conditions. And finally, we have the operational costs of handling the data that come from

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to recent research, in which, however, the project titles refer only to effects on the respiratory tract or are too general to indicate whether or not the effects of community air pollution on any of those other systems I mentioned are known at this time.

Spicer. Well, Dr. Jones, I feel that in my case you are beating a very sick dog on this question. You can appreciate that our file cabinets are now growing because we are frighteningly coming to realize that it is very dangerous for us not to make total and complete observations. This has been a hard thing for all of us to learn and, in simple answer to your question, your own survey has come close to the nub of it. We are learning this, but we are not doing very much basic work which is interdepartmental, interdivisional, or interspecialty-in-medicine as yet. However, it is more important to recognize that recognition of this difficulty of having to measure the total intact human being in his environment has caused all of us to awaken. Fortunately, several years ago the Public Health Service instituted programs aiming particularly at a multidisciplinary approach. In view of the time necessary to build and accumulate the needed facilities and to indoctrinate people into working in cross fields, a start has been made.

Mr. MacKenzie can probably comment on this better than I. I can only point out two things. First, we certainly realize the need for investigating *all* the body systems. Unfortunately, at our present infant stage, I have great difficulty in assimilating all these possibilities. Second, you will find indications that this is going to be worked out. There are already individuals who, while primarily interested in a restricted field, are studying subjects in broad

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R. C. Loehr. Professor Meyer, with these blowby devices being installed in 1963 American cars, suppose the owners neglect much of the preventive maintenance needed on these cars. What should State and local agencies do to insure that these devices remain effective throughout the life of the car?

Meyer. I believe the answer to your question may be forthcoming from California fairly soon, because its Motor Vehicle Control Board, I understand, is just now in the process of conducting hearings and deliberations for determining how continued proper operation of blowby devices is to be insured. At the moment, only factory-installed devices have been approved in California. Nothing has been done as yet on devices to be installed on cars now on the road and predating 1961. (In California blowby devices were already installed by the industry beginning with the 1961 model year.) Again, that is an area where we need to have large-scale action somewhere in order to get the broad experience data accumulated. In general, blowby devices are not difficult to maintain, and unquestionably, in a State like Pennsylvania that does have compulsory inspection, it would not be very difficult to add these devices to the items that must be semi-annually inspected and reapproved as meeting some suitable standard.

James L. Dallas. As a State regulatory official for Massachusetts, I ask your indulgence for a brief philosophical observation. As I have attended these meetings during the last few days, I have observed

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differences of opinion exist. But this should not obscure the several fundamental agreements which underlie the thinking of all of us, yet apparently receive little emphasis since they require no argument or painstaking resolution of differences. Thus it would seem, from what I have noted in this conference to date, that there is certainly fundamental

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Conference Summary

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It seems a trifle presumptuous for me to try, in a few minutes, to sum up 3 days of intensive discussion among 1,000 people, nearly all of whom know a lot more about the subject of air pollution than I do. I would guess that you have had a quarter of a million words thrown at you since Monday morning, and I'm not sure what my 2,000 will add.

Nevertheless, I'm going to try—not to summarize the whole conference—but rather to pass along to you a few impressions from the viewpoint of a man who has been breathing steadily for quite a few years and hopes to continue to do so for quite a few more.

As one who lives close to the news, I've been aware for the past few years that more and more people were talking about air pollution. Until very recently, for most of us, smog was something that happened in Los Angeles and furnished gag material for television comics. Smoke and dust

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an outsider, inevitably runs this risk and usually succumbs to it. But as I see it, there are two major points at issue.

First, shall we move full-speed ahead on the *control* of air pollution, or shall we wait until all the research results are in?

Second, who shall have the primary responsibility for making sure that air pollution is controlled?

I should like to consider these two points briefly, and then conclude with a few observations of my own.

The issue of research versus application is a familiar one. It crops up in almost every area of human endeavor—especially in those areas where application costs money. Of course, research costs money too, but research is the great white magic of our time. Nobody, but nobody, is against research. The trouble is that research doesn't clear any air until somebody uses it.

In his opening-day presentation, Dr. McAfee stated the case for continued emphasis on research, cleanly and concisely. The first three of his "Guidelines for Industrial Statesmanship" are these:

1. Be sure there is a real problem.
2. Make certain that we know what the problem really is.
3. Be sure that technically sound, economically feasible, and effective methods for solving the problem are available.

No one can quarrel with these basic premises. But how much knowledge is enough? How sure is sure?

Let's consider the health effects of air pollution. Panel C, which was charged with examination of

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On the contrary, I found great stress on the idea that local government has the primary responsibility for air pollution control. Those who spoke of increased Federal participation, including Secretary Celebrezze, Surgeon General Terry, and many others, were talking about Federal assistance to State and localities—assistance especially in the form of money to get programs going.

Dr. Terry reviewed the record of State and local spending for air pollution control. And, outside of California and a few scattered localities, the record is not impressive. In fact, it's pretty pathetic. Naively, perhaps, I wonder if the attacks on Federal enforcement aren't really attacks on Federal grants which might change dormant programs into active programs.

Besides, when it comes to air pollution, what is local? An airline pilot, on the first day of your sessions, talked of seeing the smudge from many cities blending together in a cloud which covered parts of several States. "The wind bloweth whither it listeth," and our jurisdictional lines traced on the surface of the earth have little relevance. Even those magical boundaries which separate sovereign State from sovereign State cannot check the flow of troubled air. What's a Federal Government f

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CONCLUDIN

I am sure that I express the thanks of all of us here for this able summary of 3 days of concentrated effort. We are grateful to you, Mr. Smith, for taking the time to join us here and to present both a précis and something of your own views of this national conference.

On behalf of President Kennedy and Secretary Celebrezze, and the Public Health Service, may I extend thanks to all of the members of the conference.

It is impossible in these closing moments to place any real assessment on the ultimate value of this conference. You have been dealing here with a formidable national problem—one which will engage the efforts of all of us for months and years to come. In this sharing of experience and opinion and in bringing to light different viewpoints—some of them sharply differing—you have been engaging in the kind of exercise which, in my opinion, is one of the enduring strengths of our democratic process.

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I hope that in the future, when friends and associates ask what was accomplished at the air pollution conference in Washington, each of us will think twice before saying, "Nothing much. Everybody still blames everybody else for the problem." On the contrary, we have in fact blamed ourselves and this can be the salutary first step toward action in fulfillment of a mutual responsibility.

The filters in air-sampling devices throughout the country *are* still coming out gray or black. I am not discouraged, however, for we have reached agreement on a fundamental principle: that it is every man's right to breathe air which is not a hazard to his health or property and that this right must take precedence over a great number of lesser rights, real or imagined. In so doing, we have taken an important step on the road toward a more healthful environment. We shall not arrive at our destination tomorrow or next week, but certainly sooner than we would have, had you not made your important contributions to this National Conference on Air Pollution.

I have just been informed of the telegram which has been received here from Dr. Blasingame, executive vice president of the American Medical Association. I am very happy to learn that the AMA has assumed a positive position in relation to this, a broad national problem. I should like to quote from Dr. Blasingame's message:

> The Federal Government should engage in (1) responsible leadership through the Public Health Service; (2) research and discovery; and (3) enforcement in interstate or interjurisdictional difficulties in the manner of the successfully implemented Water Pollution Act.

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APPENDIX

STAFF FOR THE
NATIONAL CONFERENCE ON AIR POLL

EXECUTIVE SECRETARY

ARTHUR C. STERN

Lucy J. Trainor, Secretary

DEPUTY EXECUTIVE SECRETARY

GENE B. WELSH

Evelyn W. Morris, Secretary

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HERMAN GORDON

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ROBERT PORTER, *Prog*
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and Administrative Unit
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ance Branch
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Education Office

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AMERICAN FARM BUREAU FEDERATION

JOHN I. TAYLOR, Assistant Legislative Director, Washington, D.C.

AFL–CIO

GEORGE TAYLOR, Research Department, Washington, D.C.

AMERICAN MEDICAL ASSOCIATION

OTIS L. ANDERSON, Manager, Washington Office, Washington, D.C.

AUTOMOBILE MANUFACT

JOHN D. CAPLAN, Chai
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CITIZENS COMMITTEE ON

SPENCER M. SMITH, J
Washington, D.C.

COUNCIL OF STATE

GEORGE BASICH, Wasl
Washington, D.C.

GENERAL FEDERATION C

MRS. DEXTER O. ARN

NATIONAL ADVISORY COMMITTEE ON COMMUNITY AIR POLLUTION

S. SMITH GRISWOLD, Air Pollution Control Officer, Air Pollution Control District, County of Los Angeles, Calif.

NATIONAL ASSOCIATION OF MANUFACTURERS

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NATIONAL ASSOCIATION OF COUNTY OFFICIALS

WILLIAM J. PHILLIPS, Chairman, Orange County Board of Supervisors, Santa Ana, Calif.

NATIONAI

HARRY C. BALLM
Control Division, '

NATIONAL TUB

BRUCE D. BENNE
Program Services I

U.S. CHAM

WALTER B. GARV
Natural Resources

U.S. CONF

JOHN J. GUNTHE
ington, D.C.

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Director of Research
Travelers Insurance (
Hartford, Conn.

JERRY McAFEE
Vice President
Gulf Oil Corp.
Pittsburgh, Pa.

MRS. EUGENE M
Washington, D.C.

STATEMENT BY THE GOVERNOR OF CALIFORNIA

EDMUND G. BROWN

Submitted to the Conference in the form of a letter to Surgeon General Terry

The State of California is very happy to participate in the National Conference on Air Pollution in Washington, D.C., December 10–12. Please extend my greeting to all of the delegates and assure them of our abiding interest in your objectives.

I am particularly impressed with the emphasis the conference places on the role of the automobile in air pollution. California now has 8 million motor vehicles, more than 10 percent of the total registration in the United States. Every vehicle is a potential contributor to the State's air pollution. But California is going ahead with a positive program to reduce motor-vehicle-created pollution, the first such program in the United States.

Along with the Federal Government, California now recognizes that motor vehicle pollution affects, to some degree, almost every urban area in the Nation. It is a problem that will continue to grow with our population and industrial expansion. It is one of the penalties of living in a mechanized society. But we are confident, too, that solutions to the problem can be found.

The control of this blight calls for continuing effort on every level of government. I would like to outline for you what we are doing on a State level and what we think the Federal Government can do.

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During the next 4 years of my second term of office, I intend to do everything that I can to return clean air to our State. We shall continue to move ahead with the motor vehicle pollution control program as rapidly as consistent with sound judgment.

Best wishes for a fruitful and successful conference.

STATEMENT BY THE AMERICAN MEDICAL ASSOCIATION

F. J. L. BLASINGAME, M.D.
Executive Vice President

Submitted to the Conference in the form of a letter to Surgeon General Terry

This letter is being written to you in order to clarify and expand on the contents of my telegram to you dated December 12, 1962, on the occasion of the National Conference on Air Pollution held in Washington, D.C., December 10–12, 1962.

My telegram was in effect a restatement and summary of the past and continued attitude and policy of the American Medical Association on the subject of air pollution. It is quite appropriate that the AMA, representing most of this nation's physicians, be interested in the control of air pollution, due to its known or suspected adverse effect on the health of our citizenry.

In April 1955, a representative of the American Medical Association appeared before the Subcom-

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STATEMENT BY THE NATIONAL ASSOCIATION OF MANUFACTURERS

SAMUEL S. JOHNSON

Chairman, Conservation Committee

Submitted to the Conference in the form of a letter to Surgeon General Terry

As a member of the Steering Committee of the National Conference on Air Pollution I was upset to find, upon seeing the printed program for the first time, that Howard K. Smith had been asked to summarize the proceedings of the 2½-day meeting, without consultation with the committee. In view of the fact that some of the most knowledgeable authorities on air pollution in the country were participants, it seemed presumptuous to use this public-relations-oriented layman for such a purpose on the program.

When it was learned that Secretary Celebrezze's statesmanlike address had been shifted to an opening place in the program, instead of closing the conference as scheduled, the industrial group appealed to Secretary Celebrezze, who asked you to meet with us, after we got no satisfaction from Mr. Arthur C. Stern. We had asked Mr. Stern to allow us to rebut the statements of Mr. Smith if he did not, in our opinion, make an objective appraisal. Mr. R. L. Ireland, who spoke to the Secretary, asked me to see you, when it became necessary for him to leave the conference. You were not available prior to the close of the conference.

It is, therefore, respectfully requested that the

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remarks, and Arthur Flemming's call for Federal enforcement. This fully distorted our feeling of the conference's consensus, obtained from the panel summaries, "that Federal enforcement was not needed and was not wanted." It was all the more reprehensible as no chance for rebuttal was permitted.

We wish to endorse for the printed record, as indicating the thinking of the industrial representatives, the statement which was delivered to the conference by Mr. R. L. Ireland, an industry member of the National Advisory Committee on Community Air Pollution. We also wish to be on record as endorsing Dr. McAfee's statement of proposed guidelines for the approach to, and the solution of, control problems. Beyond that, we endorse the following statement of Representative Kenneth A. Roberts of Alabama, chairman of the Subcommittee on Health and Safety of the Committee on Interstate and Foreign Commerce, House of Representatives: "In summary, it would seem that abatement and enforcement programs, to be effective, must remain the responsibility of State and local governments, but there is a vast field in the area of re-rch and the dissemination of information where the deral Government must continue to take the lead."

Dr. Terry and his staff are to be complimented on preparing and carrying forward a professional and informative conference. The participation of Senator Harrison Williams, cosponsor of the proposed Neuberger bill, was an obvious political maneuver. Politics being what they are, we have to accept it; but we reject the biased and distorted remarks of Howard K. Smith.

The above paragraph concludes our remarks for the printed record. It is indeed regrettable to us that such severe criticism of Howard K. Smith's comments is indicated. However, we sincerely believe that if they stand unchallenged, as purporting to convey the appraisal of this otherwise worthwhile "meeting of minds," then at some time in the future the reliability c
become suspect.

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BUREAU OF CENSUS
U.S. Department of Commerce
Washington, D.C.

ARMOUR RESEARCH FOUNDATION
Illinois Institute of Technology
Chicago, Ill.

LOS ANGELES COUNTY AIR POLLUTION CONTROL DISTRICT
Los Angeles, Calif.

BALTIMORE CITY HEALTH DEPARTMENT
Baltimore, Md.

DEPARTMENT OF AIR POLLUTION CONTROL
Chicago, Ill.

NEW JERSEY STATE DEPARTMENT OF HEALTH
Trenton, N.J.

MARYLAND STATE DEPARTMENT OF HEALTH
Baltimore, Md.

PENNSYLVANIA DEPARTMENT OF HEALTH
Harrisburg, Pa.

NEW YORK STATE DEPARTMENT OF HEALTH
Albany, N.Y.

CALIFORNIA DEPARTMENT OF PUBLIC

AMERICAN PUB
Chicago, Ill.

AMERICAN SOC
New York, N.Y.

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Detroit, Mich.

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New York, N.Y.

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Newark, N.J.

ATOMIC ENER
Washington, D.C.

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FILM PROGRAM

ARTHUR CLEARS THE AIR

An English color film dramatizing the conversion of a home heating unit to burn smokeless fuels (35 minutes).

CLEAN AIR

An English film discussing the impact of the Clean ir Act of 1956 in that country (20 minutes).

HE AT YOUR OWN RISK*

umentary film which touches on virtually all tant aspects of the air pollution problem na- ›nally. It features extensive sequences on sources, effects, and control, combined in a well-balanced manner with commentary by experts in the field (55 minutes).

THE CITY'S FUTURE*

A recent documentary which illustrates various sources of air pollution, and shows the impact of air pollution upon an urb health, economic, anc the problem are discu

CONTROL OF AIR POLL

A color film introduc problem (5 minutes).

EFFECTS OF AIR POLL

A color film stressing and a greater control e

SOURCES OF AIR POLL

A color film showing lution (5 minutes).

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